SCIENTIFIC AMERICAN SUPPLEMENT

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VOLUME LXXV]
NUMBER 1950]

NEW YORK MAY 17, 1913

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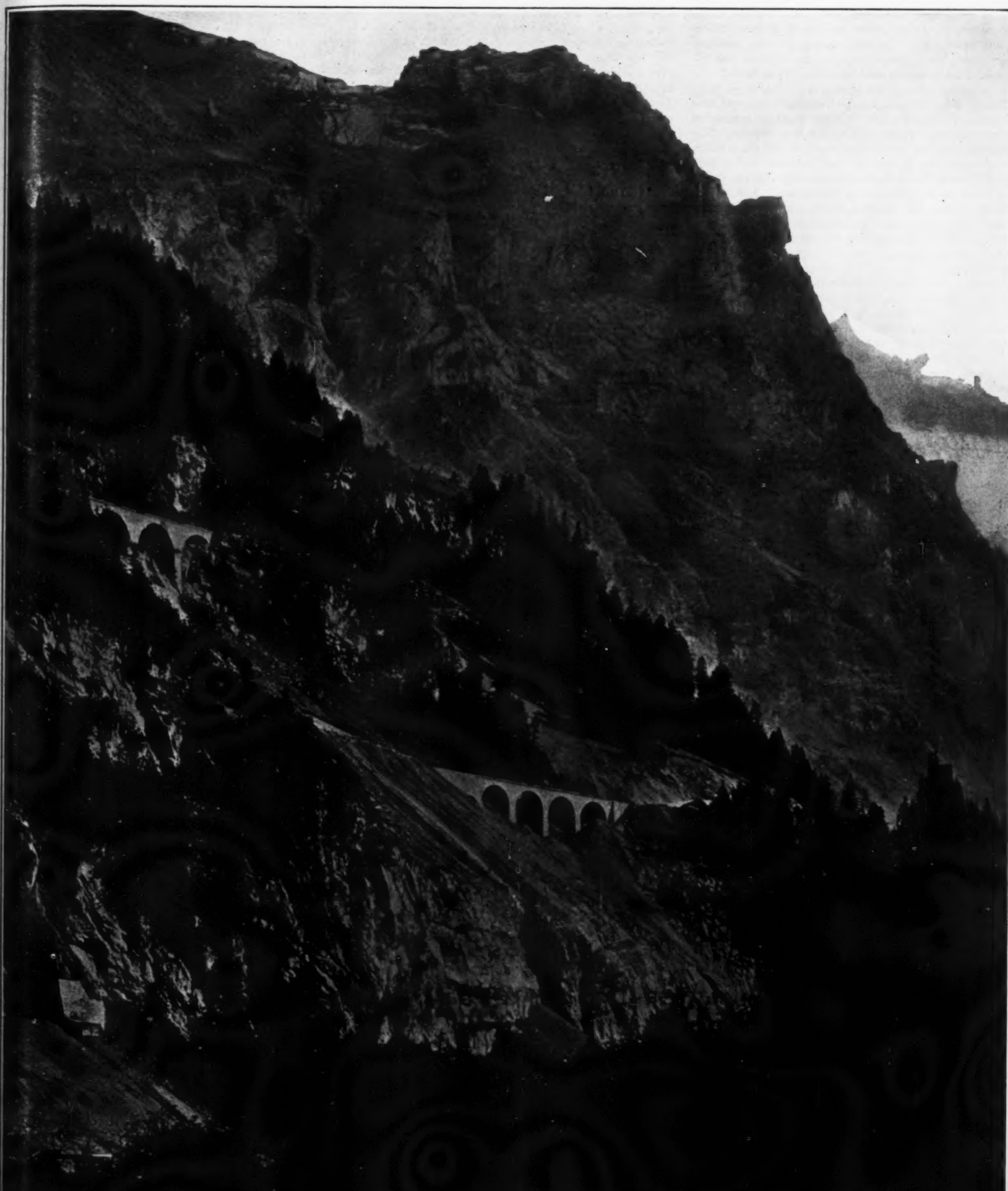


In the Kander Valley the Line Runs a Zig-Zag Course.

THE NEW LÖTSCHBERG RAILWAY, SWITZERLAND.—[See page 308.]

The Age of the Ocean*

As Determined By Its Salt Contents

By Frank Wigglesworth Clarke

The fact that we can estimate, with some approach to exactness, the absolute amount of sodium in the sea, and that it is added in a presumably constant manner without serious losses, have led to various attempts toward using its quantity in geological statistics. The sodium of the ocean seems to furnish a quantitative datum from which we can reason, whereas calcium, magnesium, silica, potassium, etc., are more or less deposited from solution, and so become unavailable for the discussion of such problems as that of geologic time.

Nearly 200 years ago Edmund Halley[1] suggested that the age of the earth might be ascertained by measuring the rate at which rivers delivered salt to the sea. The suggestion was of course fruitless for the time being, because the data needed for such a computation were undetermined, but it was nevertheless pertinent, and it now seems to be approaching realization. For reasons already given, the method proposed for estimating geologic time can as yet be only applied provisionally, the data still being imperfect, although rapidly accumulating. The present state of the problem is worth considering now.

The first really serious attempt to measure geologic time by the annual additions of sodium to the ocean seems to have been made by J. Joly[2] in 1899. Joly, with Murray's figures for rainfall, run-off, and the average composition of river water, combined with Dittmar's analyses of oceanic salts and an estimate of the mass of the ocean, deduced an uncorrected value for the age of the ocean of 97,600,000 years. The calculation is very simple, and by the following equation:

$$\frac{Na \text{ in ocean}}{\text{Annual } Na \text{ in rivers}} = \text{Age of ocean.}$$

Joly's data, however, were much less satisfactory than which, substituted in our equation, give the data now at hand.

$$\frac{14{,}130 \times 10^{12}}{158{,}357 \times 10^{3}} = 89{,}222{,}900;$$

the crude age of the ocean to which certain corrections are yet to be applied.[3] The first of these to be studied tends to increase the quotient, others to diminish it.

A part of the sodium found in the discharge of rivers. is the so-called "cyclic sodium"; that is, sodium in the form of salt lifted from the sea as spray and blown inland to return again to its source in the drainage from the land.[4] Near the coast this cyclic salt is abundant; inland its quantity is small. Joly estimates the correction for cyclic salt at 10 p. c.; but Becker in his paper on the age of the earth has discussed the isochlor evidence mathematically, and found that 6 per cent is a more trustworthy value. By Ackroyd the significance of the correction is enormously overestimated. Adopting Becker's figure, and deducting 6 per cent from the total river load of sodium, the remainder becomes 148,846,000 metric tons, which, divided into the sodium of the ocean gives a quotient of 94,712,000 years. Joly's correction of 10 per cent is very nearly equivalent to the assumption that the entire run-off of the globe, 6,524 cubic miles, according to Murray, carries on an average one part per million of chlorine. The chlorine maps, so far as they have been made, show this figure to be excessive.

The foregoing correction for "cyclic salt" is, however, not final. It has already been suggested that the wind-borne salt is only in part restored to the ocean, at least within reasonable time. Some of it is retained by the soil, if not permanently, at least rather tenaciously; and the portion which falls into depressions of the land may remain undisturbed almost indefinitely. In arid regions, like the coasts of Peru, Arabia, and parts of western Africa, a large quantity of cyclic salt must be so retained in hollows or valleys which do not drain into the sea. Torrential rains, which occur at rare intervals, may return a part of it to the ocean, but not all. Some writers, like Ackroyd, for example, have attributed the saline matter of the Dead Sea to an accumulation of wind-borne salt, an assumption which contains elements of truth, but is probably extreme. A more definite instance of the sort is furnished by the Sambhar salt lake in northern India, as studied by T. H. Holland and W. A. K. Christie.[5] This lake, situated in an inclosed drainage basin of 2,200 square miles and over 400 miles inland, appears to receive the greater part, if not all of its salt from dust-laden winds which, during the four hot, dry months, sweep over the plains between it and the arm of the sea known as the Rann of Cutch. Analyses of the air during the dry season showed a quantity of salt so carried which amounted to at least 3,000 metric tons over the Sambhar Lake annually, and 130,000 tons into Rajputana. These quantities are sufficient to account for the accumulated salt of the lake, which the authors were unable to explain in any other way.

Examples like this of the Sambhar Lake are, of course, exceptional. In a rainy region salt dust is quickly dissolved and carried away in the drainage. Only in a dry period can it be transported as dust from its original point of deposition to points much farther inland. It appears, however, that some salt is so withdrawn, at least for an indefinitely long time, from the normal circulation, and should, if it could be estimated, be added to the amount now in the ocean. Such a correction, however, would doubtless be quite trivial, and, therefore, negligible; and the same remark must apply to all the visible accumulations of rock salt, like those of the Stassfurt region, which were once laid down by the evaporation of sea water. The saline matter of the ocean, if concentrated, would represent a volume of over 4,800,000 cubic miles; a quantity compared with which all beds of rock salt become insignificant.

But although the visible accumulations of salt are relatively insignificant, it is possible that there may be quantities of disseminated salt which are not so. The sedimentary rocks of marine origin must contain, in the aggregate, vast amounts of saline matter, widely distributed, but rarely determined by analysis. These sediments, laid down from the sea, can not have been completely freed from adherent salts, which, insignificant in a single ton of rock, must be quite appreciable when cubic miles are considered. The fact that their presence is not shown in ordinary analyses merely means that they were not sought for. Published analyses, whether of rocks or of waters, are rarely complete, especially with regard to those substances which may be said to occur in "traces."

It is perhaps not possible to evaluate the quantity of this disseminated salt, and yet a maximum limit may be assigned to it. It has been shown that 84,300,000 cubic miles[6] of the average igneous rock would yield, upon decomposition, all the sodium of the ocean and the sedimentaries. The volume of the sandstones would be approximately 15 per cent of this quantity, or 12,645,000 cubic miles. Assume now that the sandstones, the most porous of rocks, contain an average pore space of 20 per cent, or 2,529,000 cubic miles, and that all of it was once filled with sea water, representing 118,730,000,000,000 metric tons of sodium. If all of that sodium were now present in the sandstones, and chemical erosion began at the rate assigned to the rivers, namely, 158,357,000 tons of sodium annually, the entire accumulation would be removed in about 750,000 years. This, compared with the crude estimate already reached for geologic time is almost a negligible quantity. The correction for disseminated salt is therefore small, and not likely to exceed 1 per cent.

The foregoing calculations, so far as they relate to the age of the ocean, imply the assumption that the rivers have added sodium to the sea at an average uniform rate, slight accelerations being offset by small temporary retardations. For the moment let us consider one phase of this suggested variability. The present rate of discharge has been hastened during modern times by human agency, and that acceleration may be important to take into account. The sewage of cities, the refuse of chemical manufactures, etc., is poured into the ocean, and so disturbs the rate of accumulation of sodium quite perceptibly. The change due to chemical industries, so far as it is measurable, is wholly modern, and that due to human excretions is limited to the time since man first appeared upon the earth. Its exact magnitude can not be determined, but its order seems to be measurable, as follows:

According to the best estimates, about 14,500,000 metric tons of common salt are annually produced, equivalent to 5,700,000 tons of sodium. If all of that was annually returned to the ocean, it would amount to a correction of about 3.25 per cent on the total addition of sodium to the sea. The fact that much of it came directly or indirectly from the ocean in the first place is immaterial to the present discussion; the rate of discharge is affected. All of this sodium, however, is not returned; much of it is permanently fixed in manufactured articles. The total may be larger, because of other additions, excretory in great part, which can not be estimated, but we may assume, nevertheless, a maximum of 3 per cent as the correction to be applied. Allowing 6 per cent, as already determined, to cyclic or wind-borne sodium, and 1 per cent to disseminated salt of marine origin, the total correction is 10 per cent. This reduces the 158,357,000 tons of river sodium to 142,521,000 tons, and the quotient representing crude geologic time becomes 99,143,000 years.

The corrections so far considered are all in one direction, and increase, by a roughly evaluated amount, the apparent age of the ocean. Other corrections, whose magnitudes are more uncertain, tend to compensate the former group. The ocean may have contained primitive sodium, over and above that since contributed by rivers. It receives some sodium from the decomposition of rocks by marine erosion, which is estimated by Joly as a correction of less than 6 per cent and more than 3 per cent on the value assigned to geologic time. Sodium is also derived from volcanic ejectamenta, from "juvenile" waters, and possibly from submarine rivers and springs. The last possibility has been considered by Sollas,[7] but no numerical correction can be devised for it. These four sources of sodium in the sea may be grouped together as non-fluviatile, and reduce the numerator of the fraction which gives the age of the ocean. Whether they exceed, balance, or only in part compensate the other corrections it is impossible to say.

From the foregoing computations it is to be inferred that the age of the ocean, since the earth assumed its present form, is somewhat less than 100,000,000 years. If, however, any serious change of rate in the supply of sodium to the sea has taken place during geologic time, the estimate must be correspondingly altered. This side of the question has been studied by G. F. Becker in the memoir already cited, who has shown that the rate was probably greater in early times than now, and has steadily tended to diminish. When erosion began, the waters had fresh rocks to work upon. Now, three-fourths of the land area of the globe are covered by sedimentary rocks or by detrital and alluvial material, from which a large part of the sodium has been leached. The accessible supply of sodium has decreased, and it may be supposed that at some remote time in the future it will be altogether exhausted. From considerations of this order Becker has developed an equation representing the supply of sodium to the ocean during past time by a descending exponential, and has shown that the age of the ocean, as deduced from the data already given, must lie somewhere between 50 and 70 millions of years. The higher figure, he thinks, is closer to the truth than the lower one. If the ocean was initially saline the estimate of its age would be still further reduced. Becker's conclusions are fairly accordant with the results derived from physical, astronomical and paleontological evidence, although the study of radioactivity among minerals has led to much higher figures for the age of the earth. It seems, however, that the rate of chemical erosion offers a more tangible and definite mode of attack upon the problem of geologic time. The problem can not be regarded as definitely solved, however, until all available methods of estimation shall have converged to one common conclusion.[8]

* A chapter from "The Data of Geochemistry," Bulletin 491 of the U. S. Geological Survey.

[1] Phil. Trans., vol. 29, 1715, p. 296. See an abstract in G. F. Becker's "Age of the Earth." Smithsonian Misc. Coll., vol. 56, No. 6, 1910; also in Science, vol. 31, 1910, p. 459.

[2] Trans. Roy. Dublin Soc., 2d ser., vol. 7, 1899, p. 23, and with later corrections, Rept. British Assoc. Adv. Sci., 1900, p. 369. Criticised by W. Mackie, Trans. Edinburgh Geol. Soc., vol. 8, 1902, p. 240; and O. Fisher, Geol. Mag., 1900, p. 124. See also V. von Lozinski, Mitt. K.-k. geog. Gesell. Wien. vol. 44, 1901, p. 74. He cites a paper by E. von Romer, Kosmos, vol. 25, 1900, p. 1, which I have not seen. Related memoirs are by E. Dubois, Proc. Sec. Sci., Amsterdam Acad., vol. 3, 1901, pp. 43, 116; vol. 4, 1902, p. 388; H. S. Shelton, chem. News, vol. 99, 1910, p. 253; Jour. Geology, vol. 18, 1910, p. 190. The presidential address of W. J. Sollas (Quart. Jour. Geol. Soc., vol. 65, 1909, p. xii) is mainly devoted to this theme. For more details see F. W. Clarke, Smithsonian Misc. Coll., vol. 56, No. 5, 1910, and G. F. Becker, idem, No. 6.

[3] These figures differ from those given in my Preliminary study of chemical denudation. In that I used Dole's data for American rivers, in which all the alkalies were reckoned as sodium alone. The new computation is based on Palmer's determinations of potassium, which must be subtracted from the former sum. The latter gave 175,040,000 metric tons Na (= K), as against the 158,357,000 Na now employed.

[4] For the quantities of salt thus transported see the table given in Chapter II. For a discussion of the significance of the correction for cyclic sodium, see J. Joly, Geol. Mag., 1901, pp. 344, 504; Chem. News, vol. 83, p. 301; and British Assoc. Report, 1900, p. 369. Also W. Ackroyd, Geol. Mag., 1901, pp. 445, 558; Chem. News, vol. 83, 1901, p. 265; vol. 84, 1901, p. 56.

[5] Records Geol. Survey India, vol. 38, 1909, p. 154.

[6] This quantity, it must be remembered, is a maximum. The true value is probably very much less, by 10 per cent or even more.

[7] Presidential address, Quart. Jour. Geol. Soc., May. 1909.

[8] A valuable summary of the evidence relative to the age of the earth, by J. Joly, appeared in Philos. Mag., 6th ser., vol. 22, 1911, p. 358.

The Comparative Efficiency of Eiffel Surfaces

Studies in Aeroplane Design

By Robert D. Andrews

The accompanying chart illustrates a new method of plotting the curves recording the drift and lift of aeroplanes. The data for the curves given are taken from the second edition of Eiffel's "Resistance of the Air and Aviation." The distinctive feature of this new method is the employment of the "Ratio of drift to lift" for the abscissae of the chart, instead of the usual "Drift." This arrangement was adopted primarily to avoid the confusion of lines produced by the other method when several curves were plotted in the same chart for purpose of comparison.

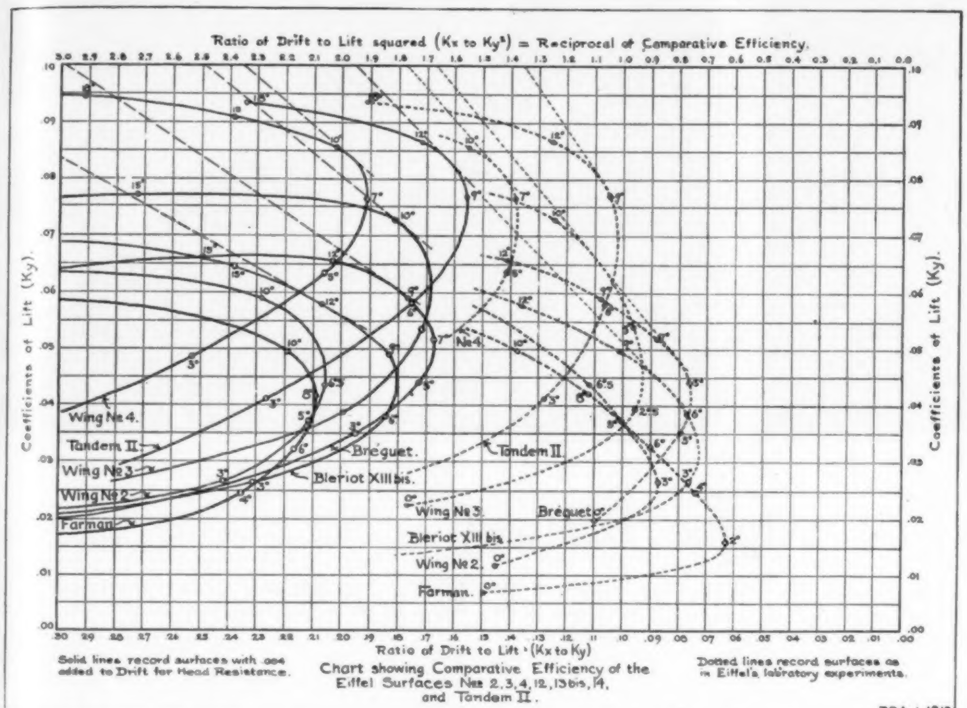


Chart showing Comparative Efficiency of the Eiffel Surfaces Nos 2, 3, 4, 12, 13bis, 14, and Tandem II.

The records of seven different types of surfaces are given in two ways; first, directly in the quantities of the laboratory tests; and second, with an addition made to the drift (Kx) to approximate the head resistance of the non-supporting parts of an actual aeroplane. The solid curves, which reckon in this added drift, therefore indicate fairly well the properties of real machines, while the dotted curves are relatively academic in character.

In addition to the advantage of clearly differentiating the several curves, this method allows the effective introduction of radial tangents from the point of origin determining for each curve its point of maximum efficiency. The maximum amount of *lift* recorded by a curve is found at the point where a horizontal line is tangent to it; and the minimum of *relative drift* —ratio of drift to lift—is determined by a vertical tangent. These two points in a curve represent two opposing virtues, both of which are included in our conception of efficiency. The energy required for propulsion being directly in proportion as the drift, the rate of expenditure per unit of lift varies as the ratio of drift to lift. The higher this ratio, the higher the rate of cost in horse-power. But as the angle of incidence of least relative drift is the lowest angle compatible with horizontal flight, and as this angle must be increased to increase the amount of lift, the rate of horse-power expenditure has to be increased with increase of lift. Up to a certain point in the curve the increase of lift is relatively greater than the increase in cost required to produce it. But beyond this point the cost increases more rapidly than the gain in lift. Therefore this point represents a mean between the two virtues of *low relative drift* and *high lift*, and it is this point in the curve which we designate as the point of maximum efficiency. In terms of the chart, the ratio of relative drift to lift is expressed as $\frac{Kx}{Ky} \div Ky$, or $\frac{Kx}{Ky_2}$. At the point of maximum efficiency the value of $\frac{Kx}{Ky_2}$ is less than at any other point in a given curve. This value is read in the scale at the top of the chart where met by the extended radial.

The purpose of plotting several curves in the same chart is to enable us to compare their maximum efficiencies. In practice it will be convenient to know what type of surface will prove to be the best carrier. If, for example, an army commander wants to occupy a certain hilltop accessible to him only by aeroplane, and needs to get a hundred men with guns and ammunition there during a few brief hours of nightime, it will be of vital importance to have aeroplanes of the most efficient type of surface. If one type of machine can carry twice as much profitable load as another, the second machine must make two flights to the former's one to accomplish the same task; and furthermore, to do the work in the same time, must be twice as fast. From the commercial as well as the military point of view, these considerations are of primary importance.

It is assumed that in all cases of comparison the supporting areas of the surfaces are equal; so also are their speeds in flight. This assumption follows from the fact that in the Eiffel records K is invariably the resistance in kilogrammes of a unit of surface, S, one square meter in area, meeting the air with a relative velocity, V, of one meter per second. Whatever values may be given to S and V, the fact remains that these values are uniform and constant for all compared surfaces. The aspect ratio also is uniform. Since all the compared surfaces are equal in area, it is reasonable to assume that all the machines embodying them are substantially the same in weight and strength, and in the amount of head resistance presented by their non-supporting parts as has already been provided. These assumptions place the criterion of efficiency solely upon the type of wing surface, i. e., the sectional form, camber, or, as in the case of the Tandem, the dispositions of the surface.

We find it stated at the top of the chart that the readings Kx/Ky^2 equal *the reciprocal* of comparative efficiency. For example, the reading of the radial tangent to the dotted Tandem curve is 1.35, whose reciprocal is $\frac{1}{1.35} = 0.74$. The next reading is that common to Wing No. 3 and the Briguét wing—1.67—whose reciprocal is $\frac{1}{1.67} = .60$. By the use of these reciprocal values of the readings, the higher value attests the higher efficiency, as is logically desirable.

To determine the actual efficiency of the several types of surface recorded in these curves, we have calculated for each the horse-power required to maintain them at equal speeds, and the results are given in an adjoining table. *We define the efficiency of an aeroplane to be the ratio of the number of kilogrammes of lift to the number of horse-power expended per kilogramme of lift.* As the number of kilogrammes of lift is expressed by the term Ry, and number of horse-power per kilogramme of lift by the term $\frac{HP}{Ry}$, the ratio is written,

$$\text{Efficiency, } E = Ry \div \frac{HP}{Ry} = \frac{Ry^2}{HP};$$

$\frac{Ry_2}{HP}$ is resolved as follows:

$$Ry^2 = K^2S^2V^4$$

$$HP = Rx\frac{V}{75} = KxSV^2\frac{V}{75} = Kx\frac{SV^3}{75}$$

$$\therefore \frac{Ry^2}{HP} = \frac{Ky^2S^2V^4}{Kx\frac{SV^3}{75}} = \frac{Ky^2}{Kx} \times \frac{S^2V^4}{SV^3} \times \frac{75}{1} = \frac{Ky_2}{Kx}75SV$$

Since $\frac{Ky^2}{Kx}$ and $\frac{Kx}{Ky^2}$ are reciprocals.

The reciprocal of $\frac{Kx}{Ky^2} \times 75SV = E$, Efficiency.

As $\frac{Kx}{Ky^2}$ is the reading of the radial tangents at the top of the chart, when the reciprocal of any such reading is multiplied by 75 SV, the product is the actual numerical ratio of the number of kilogrammes of lift to the number of horse-power expended per kilogramme of lift. Whatever values may be given to S and V, 75 SV is a constant for all compared surfaces; hence the reciprocal of $\frac{Kx}{Ky^2}$ as determined on the chart is a measure of the comparative efficiency of the several surfaces.

Self-Winding Clock Operated from Water Mains

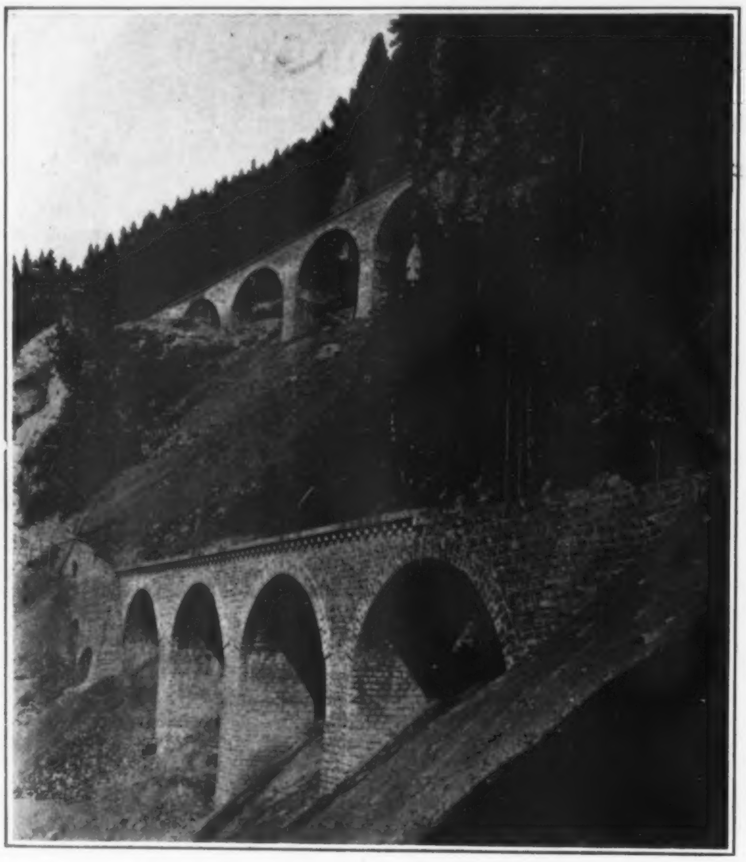
Various schemes have been devised for the construction of self-winding clocks. Whether such clocks possess sufficient advantage to warrant the expenditure of much ingenuity upon them may be left an open question. But ingenious certainly is the proposal of a French inventor to use the variations in the pressure in water mains to actuate a ratchet wheel arrangement whereby a clock can be kept perpetually wound up. As the water mains are constantly being tapped by different users, there are frequent fluctuations in the pressure, and these are made use of by the inventor.

TABLE OF FIGURES SHOWING THE COMPARATIVE EFFICIENCY OF EIFFEL SURFACES IN TERMS OF HORSE-POWER.

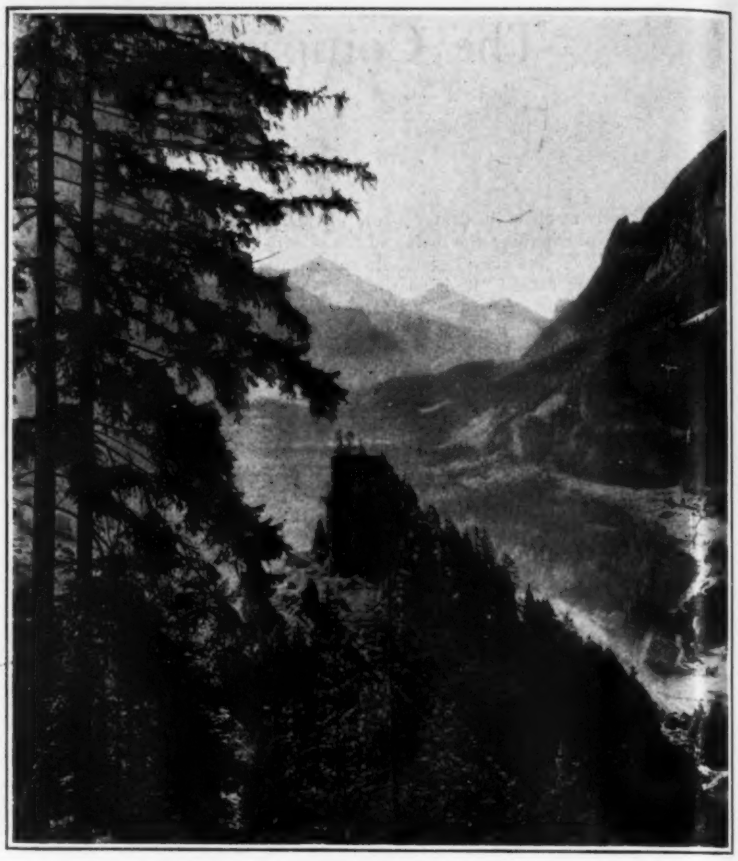
The Values given are those of the Points in the Solid Curves of the Chart, where Radials are Tangent. $S=20$, $V=30$

Type of Surface.		Tandem II.	Wing No. 4	Wing No 3	Bréguet.	Blériot.
Chart Reading	Kx/Ky	0.163	0.197	0.178	0.181	0.205
Chart Reading	Ky	0.083.	0.084	0.072	0.061	0.057
Coefficient of Drift	Kx	0.0135	0.0165	0.0128	0.0110	0.0117
Total Drift in Kilogrammes	Kx	0.243	0.297	0.230	0.198	0.211
Total Lift in Kilogrammes	Ky	0.1494	0.1512	0.1296	0.1098	0.1026
Total Horse-power	HP	97.2	119.0	92.0	79.0	84.0
HP per Kilogramme of Lift	HP/Ry	0.065	0.079	0.071	0.072	0.082
Ratio of number of Kilogrammes of Lift to HP per Kilogramme	Ry^2/HP	22,963	19,211	18,250	15,122	12,580
Reading in upper scale	Kx/Ky^2	1.96	2.34	2.47	2.96	3.60
Reciprocal of Reading	Ky^2/Kx	0.510	0.427	0.405	0.338	0.278
Constant, S=20, V=30	75 S V	45,000	45,000	45,000	45,000	45,000
Efficiency	E	22,950	19,215	18,225	15,210	12,510

Note.—The slight variations in the amounts of Ry^2/HP and E is solely due to not carrying all the figures out to a sufficient number of places from the decimal. They are algebraically shown to be equal.



The New Line Passes Over Many Viaducts in Its Ascent.



The Ruins of the Felsenburg, in the Kander Valley, Felsenburg.

A New Alpine Railway

A GREAT work is nearing completion in the heart of the Alps which has been carried on during the past six years at the cost of $20,000,000 and of many human lives. This is the Bernese Alps Railway—a line which, although but 48 miles in length, has a history going back some fifty years. The chief canton of Switzerland, Berne, long cherished the idea of a great international highway which should run through its territory *en route* from north to south. The difficulties presented by the nature of the country, however, caused the continual postponement of the project, and in the meantime Berne co-operated with the rest of Switzerland in building the Gotthard and Simplon lines.

After many vicissitudes and a long series of parliamentary debates, the scheme of a line which should transect the Bernese Alps was at last definitely adopted in 1906, and the work was started in the same year. It would be no exaggeration to say that the building of the Bernese Alps Railway was one of the most difficult railway engineering feats ever undertaken. Not only was it necessary to pierce a tunnel through the immense *massif* of the great Bernese Alps range, but the line on either side of this nine-mile-long tunnel had to be carried through wild, precipitous country where the laying of a railway track was accompanied by almost insuperable difficulties and many dangers. Material had to be conveyed into remote valleys where the only means of progress was by means of a mule-path, and thousands of workmen had to be accommodated for the space of years in country hitherto almost uninhabited.

The new line starts at Spiez, on the beautiful Lake of Thun, and proceeds *via* Frutigen to Kandersteg, where the northern portal of the great tunnel is situated. The first section of the line, from Spiez to Frutigen, has been open for some time, and here the trials of the powerful electric locomotives destined for the Lötschberg service have taken place. These electric locomotives are the most powerful alternating current locomotives in the world, and it is interesting to note that each can do the work of two Gotthard steam locomotives, being capable of hauling a train of 310 tons on a gradient of 1:37 at a speed of 26 miles an hour.

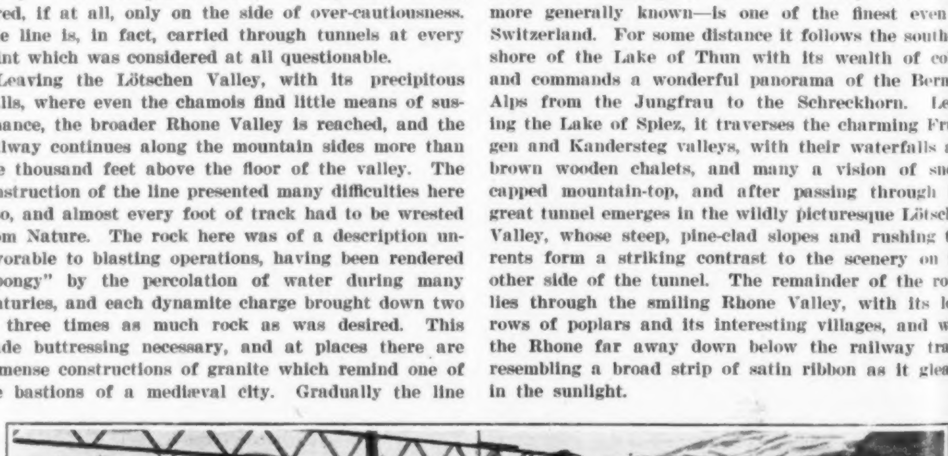
The line is carried over a magnificent viaduct of thirteen arches after leaving Frutigen, and thence follows the left side of the Kandersteg Valley. A series of fine embankments, graceful bridges and viaducts overcomes the natural obstacles offered by the terrain, and midway between Frutigen and Kandersteg there is an interesting point where the railway describes a gigantic loop and the track crosses three times at different levels.

At Kandersteg the line enters the tunnel, which was four and a half years in making, and emerges on the other side of the mountain range at Goppenstein in the wild Lötschen Valley. Here in this inhospitable and avalanche-swept spot elaborate precautions have been taken to prevent the destruction of the line by falls of snow masses, barriers having been constructed at intervals up the mountain side to break their force, while the track itself is guarded for some distance by a mighty granite wall. One is reminded that these precautions are not superfluous by the sight of the trim graveyard where the numerous workmen who have met their death during the construction of the line are buried. No fear need be entertained regarding the safety of the completed track, the engineers having erred, if at all, only on the side of over-cautiousness. The line is, in fact, carried through tunnels at every point which was considered at all questionable.

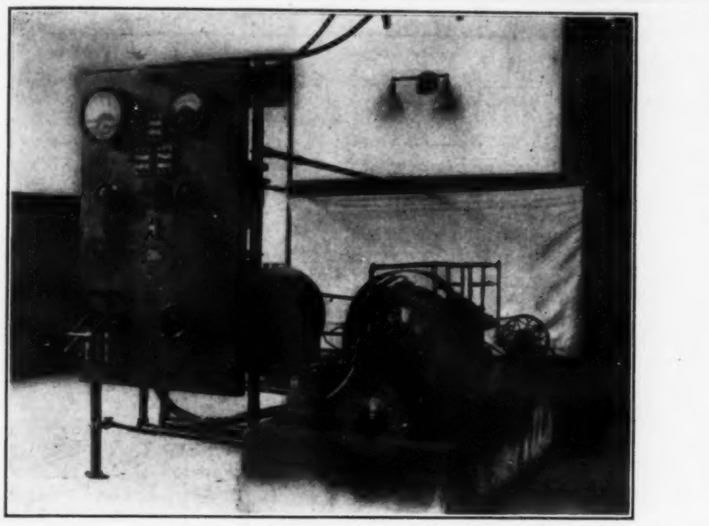
Leaving the Lötschen Valley, with its precipitous walls, where even the chamois find little means of sustenance, the broader Rhone Valley is reached, and the railway continues along the mountain sides more than one thousand feet above the floor of the valley. The construction of the line presented many difficulties here also, and almost every foot of track had to be wrested from Nature. The rock here was of a description unfavorable to blasting operations, having been rendered "spongy" by the percolation of water during many centuries, and each dynamite charge brought down two or three times as much rock as was desired. This made buttressing necessary, and at places there are immense constructions of granite which remind one of the bastions of a mediæval city. Gradually the line descends until Brigue is reached, and here the junction with the Simplon line is effected.

The advantages of the new line, which will be opened in May next, are many, and from certain places a saving of three or even four hours will be effected on the journey to Italy, with a corresponding reduction in the fare. Travelers *via* Delle or Basle will effect a saving of more than an hour, as the long detour formerly necessary in order to reach the Simplon will be avoided; the main object of the line is, in fact, to afford a short cut to the Simplon, which has suffered hitherto owing to its remote situation.

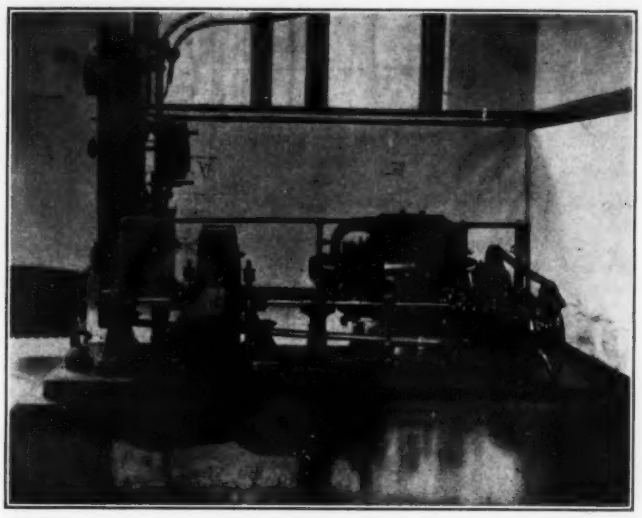
From a scenic point of view the Bernese Alps Railway—or Lötschberg, to use the name by which it is more generally known—is one of the finest even in Switzerland. For some distance it follows the southern shore of the Lake of Thun with its wealth of color, and commands a wonderful panorama of the Bernese Alps from the Jungfrau to the Schreckhorn. Leaving the Lake of Spiez, it traverses the charming Frutigen and Kandersteg valleys, with their waterfalls and brown wooden chalets, and many a vision of snow-capped mountain-top, and after passing through the great tunnel emerges in the wildly picturesque Lötschen Valley, whose steep, pine-clad slopes and rushing torrents form a striking contrast to the scenery on the other side of the tunnel. The remainder of the route lies through the smiling Rhone Valley, with its long rows of poplars and its interesting villages, and with the Rhone far away down below the railway track, resembling a broad strip of satin ribbon as it gleams in the sunlight.



The Lötschberg Electric Locomotives of 2,000 Horse-power are the Most Powerful in Europe.



Alexanderson High-frequency Dynamos and Switchboard.



High-frequency Two-kilowatt Dynamo, With Motor and Delaval Gear.

Propagation of High-Frequency Electric Waves Along Wires—I*

Advantages and Limitations of the System for Practical Operation

By John Stone Stone

For the past three years or more Maj. Geo. O. Squier, of the Signal Corps of the United States Army, has conducted a systematic investigation of the propagation of high-frequency electric waves along wires and of the practicability of their use in the transmission of signals and of speech along actual telephone cables and air lines. His investigations have also dealt with electrical resonance as a means of segregating, at the receiving end of the line, high-frequency currents of different frequencies simultaneously propagated along the line, and the selective reception of the energies of these different currents, each in a different receiver circuit made responsive only to the variations in the amplitude or strength of the current it is resonantly tuned to receive. The results of his labors are to demonstrate beyond a peradventure that not only Morse signals but speech may be transmitted over the ordinary telephone cable and pole line circuits and to very considerable distances by means of high-frequency electric currents or waves, and that a large number of telegraphic or telephonic messages may thus be transmitted simultaneously over a given telephone or telegraph circuit without interfering with each other through the use of electrically tuned or electrically resonant receivers. Moreover, he has shown that the new high-frequency multiplex telegraph and telephone system may be superimposed on the older systems or the new high-frequency apparatus added to lines equipped with the usual telegraph or telephone apparatus without interfering in any way with the operation of this older apparatus or being interfered with by it.

The frequencies of the electric waves or currents propagated along the wires in this new art are, so to speak, "above the limit of audibility of the receivers" or are ultra-sound frequencies. In other words, each of the electric currents propagated along the telegraph or telephone line is of so high a frequency that it can produce no audible effect in the telephone receiver through which it passes as long as its strength or amplitude remains constant. In fact, the frequencies of the currents used in this new telegraphy and telephony are 20,000 or more alternations per second, and correspond, therefore, to the frequencies of the air vibrations of sounds whose pitches are above the limit of audibility of the human ear. In the new telegraphy and telephony, the telegraphic signals and the voice are transmitted over the line wire by suitable variations in the amplitude or strength of the otherwise uniform high-frequency current, and the signals and the voice are received in a magneto telephone receiver connected in a local circuit which included a device capable of rectifying the high-frequency current used. The rectifier employed is preferably an Audion,[1] though a Wollaston[2] electrode and perhaps other radio-telegraphic detectors, particularly the so-called crystal rectifiers, may also prove serviceable.

The rectifier in the local circuit at the receiver converts the high-frequency current of the line wire into a pulsating current of double the frequency, or, what is the same thing, it converts the high-frequency current into a normally uniform unidirectional current with a superimposed alternating current of double the frequency of the line current. The telephone receiver is mute to the alternating component of the rectified current, but responds to the most minute variations in the strength of the unidirectional component of this current. Variations in the amplitude or strength of the high-frequency line current are faithfully reproduced in the strength of the unidirectional component of the local receiver current, and in this way the telephone receiver is made highly sensitive to variations in the strength of the high-frequency line currents, while absolutely mute to that current when its amplitude is constant.

The relation of the new high-frequency telegraph and telephone to radio-telegraphy and radio-telephony is to be readily seen in Fig. 1, which illustrates the new system in its simplest practical form. The diagram shows, in fact, two radio-telegraph or radio-telephone stations with a connecting wire between them to guide the waves from the transmitter to the receiver.

In this arrangement the current is supplied by a high-frequency alternating current dynamo A, which must be capable of supplying 20 watts at 10 volts and at not less than 20,000 cycles per second. These requirements are more than met in the Alexanderson high-frequency dynamo,[3] which has already been constructed to a capacity of at least 2 kilowatts and develops at its highest speed currents of 100,000 cycles per second. In the case of high-frequency telephony this dynamo has to meet a further requirement which is not demanded of it by high-frequency telegraphy, and this requirement is perhaps the most difficult one to satisfy. It is that the amplitude of the current the dynamo supplies must be absolutely smooth and can have no variations or ripples on it of periods corresponding to the periods of audible tones. In this connection the author noted that a 2-kilowatt Alexanderson dynamo gave a loud musical tone in the telephone at the receiving end of the line when the dynamo was worked with the normal separation between the stator and rotor, and he found it necessary to increase the air gap to a point at which the capacity of the dynamo was about one eighth of its normal rated capacity before a quiet line was secured. Even at this adjustment, the dynamo had more than ten times the required capacity.

Owing to the small amount of energy required of the dynamo, there is no particular difficulty in constructing machines to meet the demands, very unusual though they be, particularly in the case of high-frequency telephony. It is not likely, however, that high-frequency dynamos will long be used in this connection, because oscillators giving sustained oscillations or continuous trains of waves of ultra-sound frequencies, constructed on the general principle of the Elihu Thomson oscillator,[4] are much cheaper and less cumbersome than the dynamo, while requiring less care and skill in their operation.

In the arrangement of apparatus illustrated in Fig. 1, when the switches at the transmitter and at the receiver are both thrown up as shown, the arrangement is a high-frequency telephone system, while when the switches are both thrown to their lower contact points the arrangement becomes a high-frequency telegraph system, so that the one diagram may be used to sketch the operation and requirements of both the new telegraph and the new telephone.

In the new telephone system, when the transmitter T is spoken to, it modifies the amplitude of the high-frequency current in the primary circuit of the induction coil I_1 in exactly the same way that it modifies the strength of the battery current in the primary circuit of the induction coil in the old telephone system, and, as already described, the telephone receiver R at the receiving station responds, owing to the fact that exactly corresponding fluctuations result in the unidirectional component of the rectified current in the local circuit at that station.

In the new telegraph system the operation of the telegraph key K, to send Morse signals, alternately throws the high-frequency current on the line and cuts off the supply of this current from the line. The result of this would be only to make successive faint clicks in the telephone receiver R as the current is thrown on and off, except for the periodic interrupter B, which may be of the nature of a revolving commutator or a mere buzzer. This interrupter serves to break the incoming wave trains constituting the Morse signal elements up into a succession of much shorter wave trains having a frequency of about 450 impulses per second, which when rectified give rise in the telephone receiver to a high pitched musical tone of great audibility. The Morse signals now are audible as a succession of long and short intervals of a high-pitched musical sound, as in radio-telegraphy. From the foregoing and the diagram of Fig. 1 the essential differences between the new telegraphy and the new telephony will easily be seen.

Some of the more essential characteristics of the simple system shown in Fig. 1 may prove of interest, particularly as they have not as yet, so far as I am aware, been clearly set forth. The induction coils I_1 and I_2 are wound without any iron in their cores, since in the first place the presence of iron is not needed to secure a large mutual inductance between the primary and the secondary circuits, because a high degree of coupling[5] between these circuits is not desirable, and, in the second place, the presence of iron in the core of the coils would introduce a loss of energy, through hysteresis, owing to the high frequencies used, which would give rise to an effect equivalent to the presence of a considerable dissipative resistance in the primary and in the secondary circuits. The arrow through the symbols for the coils indicates that these coils are adjustable with respect to their degree of coupling in the same way and for the same reason that the coupling of the corresponding coils is made adjustable

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[1] *Proc. Inst. Elect. Eng.*, xxv, pp. 219-247, 1906. *Elect. World*, xlviii, p. 1,109, 1906. *Ibid.*, xlviii, p. 1,186, 1906. U. S. Patent No. 879,532 of 1908 to de Forest, and U. S. Patent No. 884,110 of April 7th, 1908, to J. S. Stone and S. Cobat.

[2] Paper by Dr. Wm. H. Wollaston, *Phil. Trans. of the Royal Soc. of London*, vol. 91, part ii, pp. 430-432, published 1801.

[3] *Trans. Am. Inst. Elec. Eng.*, vol. xxvii, p. 399.

[4] U. S. Patent to Elihu Thomson, No. 500,630 of July, 1892.

[5] The coupling coefficient of the induction coil is $\dfrac{M}{\sqrt{L_1 L_2}}$, where M is the mutual inductance, and L_1 and L_2 are the inductance of the primary and secondary coils, respectively.

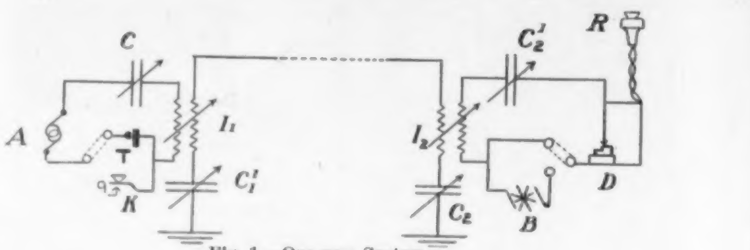


Fig. 1.—One-way System.

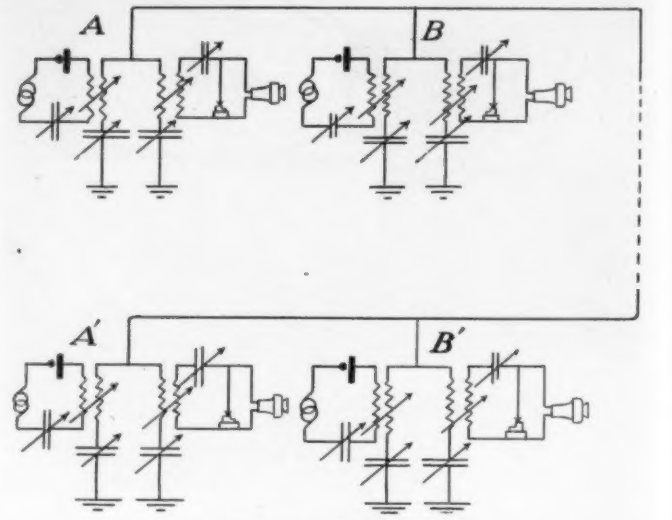


Fig. 2.—Duplex System.

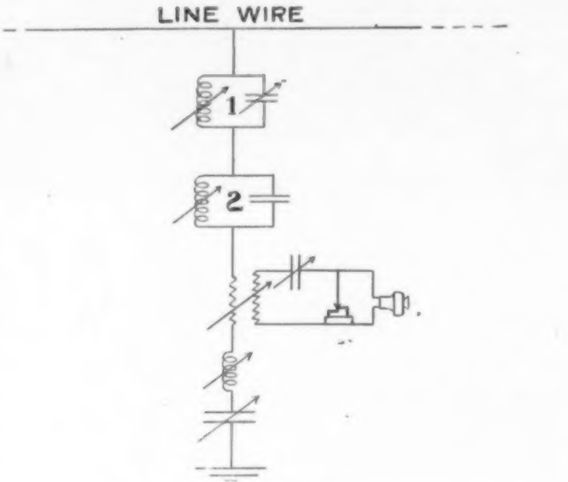


Fig. 3.—Multiplex System.

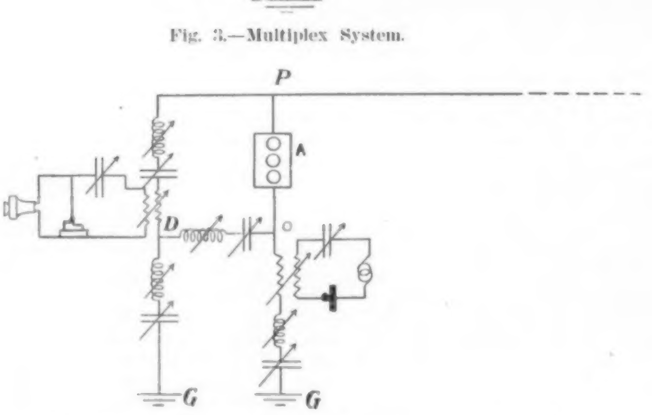


Fig. 4.—Receiver Irresponsive to Transmitter of Same Station.

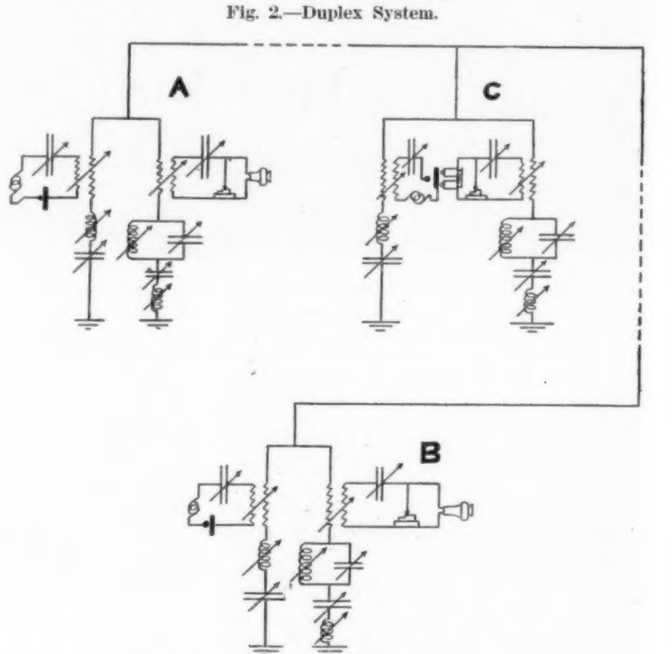


Fig. 5.—Telephone Amplifier for Two-way Transmission.

in radio-telegraphy and radio-telephony. Similarly, the arrows through the symbols for the condensers $C_1C'_1C_2$ and C'_2 indicate that these condensers are of adjustable capacity.

The function of the variable condensers at the transmitting and receiving stations is to electrically "tune" these stations. In the transmitting station of the system shown in Fig. 1, the so-called tuning is quite different in the case of the telephone and telegraph systems. In the case of the telegraph, the coupling of the coil I_1 and the capacities of both condensers at the transmitter are adjusted with reference to the production of a maximum current in the line wire, as indicated by a hot wire ammeter connected in the secondary circuit. In the case of the telephone system, the coupling of the coil I_1 is made very small, and each of the condensers at the transmitting station is then independently adjusted to make the current in the circuit in which it is included a maximum, as indicated by hot wire ammeters connected in each circuit. The coupling of the transmitter coil is then increased till the tuning adjustment of one circuit interferes with the tuning adjustment of the other, and the circuits are readjusted, each by its own condenser, for a maximum of current in itself. The reason for the radical difference in the tuning of the transmitter station in the telephone and telegraph systems may not be obvious. It is due to the fact that in the telegraph it is the actual amplitude of the high-frequency waves propagated along the line that determines the strength or loudness of the signals heard in the receiver, while in the telephone system it is the magnitude of the *variations in amplitude* of the high-frequency waves propagated along the line that determines the loudness of the received speech. Moreover, in the case of the telegraph the loudness of the received signal is the sole object, while in the case of the telephone a still more important requirement is excellence in the quality or articulation of the transmitted speech. In the case of the telegraph, therefore, the adjustment of the transmitter station is such as to produce the maximum amplitude of the transmitted waves, while in the case of the telephone system the adjustment is primarily adapted to securing the best quality of the transmitted speech, and, incidentally, to produce the maximum *variation in amplitude* of the transmitted waves.

Thus, by loosely coupling the primary and secondary circuits at the transmitter and then adjusting the primary circuit for a maximum or current, the reactance of the primary is made zero and the impedance of the primary is reduced to practically the mere resistance of that circuit, so that the resistance of the telephone transmitter becomes practically the sole factor in determining the primary current. Obviously this makes the variations in the amplitude of the high-frequency current due to variations in the resistance of the telephone transmitter a

Fig. 6.

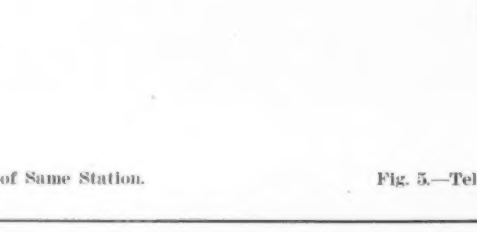


Fig. 7.

maximum, and, on the other hand, telephone engineers will realize that the elimination, so far as possible, of all reactance and resistance except that of the telephone transmitter, from the primary circuit at the transmitter station, is a prerequisite to good quality or articulation of the transmitted speech.

At the receiving station of the system shown in Fig. 1, whether it be used as a telegraph or a telephone system, the tuning of both primary and secondary is directed merely to the production of a maximum current in the secondary circuit, and for this tuning the telephone receiver is used as the indicating device, since the current at the receiving station is not sufficient to permit of the use of a hot wire ammeter. A sensitive galvanometer may sometimes be used with advantage for tuning purposes in place of the telephone receiver.

The system shown in Fig. 1 is obviously not of much general utility, since it provides only for one-way transmission. It is shown and described at some length merely because of its simplicity and to bring out the analogies and the distinguishing features of the new telegraph and the new telephone systems.

A duplex system of high-frequency telephony with two-way transmission for each station is shown in Fig. 2. Again, the simplest practicable arrangement is shown merely for the purposes of illustration, the more complex but more perfect multiplex station being shown in Fig. 3. Each station of the system shown in Fig. 2 combines a transmitter and receiver identical as to apparatus with the transmitter and receiver shown in Fig. 1, and differing from the simplex system of that figure only in the tuning of the stations. In this duplex system the frequency to which a given receiver is adjusted to respond is as remote as it can conveniently be made from that of the current generated by the transmitter as its own station and from that of the adjacent stations; thus if stations *A* and *A'* intercommunicate while stations *B* and *B'* intercommunicate, for transmitters of *A* and *B* might make use of frequencies of current of, say, 20,000 and 22,000 cycles per second, respectively, while the trans-

mitters of stations A' and B' made use of frequencies of 60,000 and 66,000 cycles per second, respectively. Of course, then, the receivers of stations A and B would be adjusted to respond to currents of 60,000 and 66,000 cycles, respectively, while the receivers of stations A' and B' would be adjusted to respond to currents of 20,000 and 22,000 cycles, respectively.

The tuning of the apparatus in the duplex system of Fig. 2, or even of the apparatus of a simplex system with two-way transmission, is not the same as that of the apparatus of the simplex system of Fig. 1, for the reason that in the duplex system and in the two-way transmission simplex system the new element of selectivity is required of the apparatus.

It might not at first seem necessary in a duplex or multiplex system to make the transmitter circuits selective, since the frequency at a transmitter is completely determined by the generator adjustment or the dynamo speed at that station, irrespective of any tuning of its circuits, but on closer examination it will be seen that were a transmitter branch circuit not tuned in such a way as to make it receptive of the current generated at that station and exclusive of currents of other frequencies, currents of all the frequencies used on the line would flow through it, and the variations of resistance of the telephone transmitter or manipulation of the telegraph key in the local circuit at that transmitter station would modify not only the amplitude of the current generated at that station, but would also modify the amplitude of the currents of other frequencies as well, and cause "cross talk" between stations on the line not intended to communicate with each other. Each branch, whether it be a transmitter or a receiver branch circuit, is so tuned that it has *per se*, that is, when disconnected from the line and short-circuited on itself, a minimum of impedance for currents of the frequency it is to select.

The simplest way to accomplish this tuning is to disconnect the branch and local circuit from the line, make the coupling of the coil very small and tune each circuit for a maximum of current by the adjustment of its own condenser. After this preliminary tuning, the coupling may then be increased to any desired extent and the final tuning for maximum current be easily effected. In the case of a receiving station it is in general desirable, in order to secure maximum selectivity, to employ a small coupling, and in tuning the apparatus of a receiving station the electromotive force is impressed upon the primary circuit. In a transmitter coil it is in general desirable to use a somewhat larger coupling, though maximum coupling is never advantageous, and in tuning a transmitter apparatus the electromotive force should be impressed on the primary for tuning the primary and on the secondary for tuning the secondary. The secondary branch of the transmitter is connected to the line while the primary is being tuned, and is short-circuited on the source of electromotive force[6] and the ammeter when being tuned itself. Of course, the tuning of a primary circuit disturbs the tuning of the associated secondary circuit, and *vice versa*, and the extent of this disturbance is roughly proportional to the square of the coupling coefficient between the circuits. As a result, the proper tuning of these stations is a matter of successive approximations, but with the small couplings which it is of advantage to use in order to secure a maximum degree of selectivity, two or three successive, alternate adjustments of the condensers in the primary and secondary circuits only are necessary, particularly after one has had some experience in tuning coupled circuits. As these tunings are of the nature of calibrations and are made once for all for a given frequency, they do not appear to constitute a valid objection to the system on the ground of their complexity or on the ground that they require special skill.

As already stated, the duplex system illustrated in Fig. 2 is a very simple form of the new system, but serves well to illustrate the general characteristics of a high-frequency multiplex system. It lacks, however, a feature the absence of which makes it necessary to choose remotely different frequencies for the use of adjacent transmitters and receivers, a fact which would, in many instances, place an arbitrary restriction on the use of wide ranges of frequencies and seriously limit the number of stations which could be simultaneously operated on a single line. The author has devised means which have overcome this difficulty, and three characteristic examples of this means are illustrated in Figs. 3, 4 and 6.

In Fig. 3 the receiver circuit is shown alone, and it is to be noted that in the branch from the line wire there are two loop circuits, 1 and 2, each consisting simply of a condenser and a coil. These loop circuits are each made resonant *per se* to one of two frequencies, current of which frequenices it is particularly desired to exclude from the receiver. Thus if this receiver were to be used at stations A or B of Fig. 2, its loop circuits 1 and 2 would be individually made resonant, each to one of the two frequencies generated by the transmitters of stations A and B, while if it were used at one of the stations A' or B', its loop circuits would individually be made resonant each to one of the two frequencies generated at the transmitters of stations A' and B'. The effect of the presence of one of these looped resonant circuits in the receiver branch is practically to make the branch electrically opaque to currents of the frequency to which the loop is made resonant. So great may be made the impedance of such a loop circuit to high-frequency currents of that particular frequency to which it is attuned that it is possible to operate a system in which the receivers are thus protected against the currents from the transmitters at their own station and at adjacent stations with less than 10 per cent difference between the frequencies of the transmitters and receivers. If the apparent resistance presented by a loop circuit be called R' and the apparent reactance of the loop be called K', then

$$R' = \frac{R}{R^2 C^2\omega^2 + (CL\omega^2 - 1)^2}$$

and

$$K' = -L\omega \frac{R^2C/L + (CL\omega^2 - 1)}{R^2C^2\omega^2 + (CL\omega^2 - 1)^2}$$

where R and L are the resistance and inductance respectively of the coil, C is the capacity of the condenser and ω is the periodicity of the current or 2π times the frequency.

When the loop is resonant to the frequency of the current, $CL\omega^2 = 1$, making

$$R' = \frac{L}{CR}$$

and

$$K' = -\frac{I}{C\omega}$$

If in a given case the periodicity be 200,000, corresponding therefore, to a frequency of 31,850, and if the inductance and resistance of the coil be five millihenrys and one ohm, respectively, then the capacity will be 5×10^{-9} farads. In the case of such a loop, therefore, the apparent resistance of the loop to the currents it is designed to obstruct is one megohm, while the apparent reactance of the loop is one thousand ohms.

The presence of these loop resonant circuits in the receiver branches does not interfere with the tuning of the branches to the frequencies to which the latter are required to respond; in fact, the loop resonant circuits assist in such tuning, since for frequencies of currents higher than that, the passage of which a given loop circuit is adjusted to obstruct, the loop circuit presents an apparent capacity reactance and but small apparent resistance, while for frequencies of current lower than that, the passage of which it is adjusted to obstruct, the loop presents an apparent inductance reactance with but small apparent resistance. These apparent capacity and inductance reactances are balanced by the adjustable inductance and capacity reactance, respectively, of the branch so as to make the branch selectively receptive of currents of the desired frequency.

For currents of a periodicity ω_1 which is n times that to which the loop is made resonant, the apparent resistance and reactance of the loop are:

$$R' = \frac{R}{n^2R^2\frac{C}{L} + (n^2 - 1)^2}$$

and

$$K' = -nL\bar{\omega} - \frac{R^2\frac{C}{L} + n^2 - 1}{n^2R^2\frac{C}{L} + (n^2 - 1)^2}$$

In the case of the particular loop circuit just considered

$$R' = R/\{10^{-6}n^2 + (n^2 - 1)^2\}$$

and

$$K' = -10^3 n \frac{10^{-6} + n^2 - 1}{10^{-6}n^2 + (n^2 - 1)^2}$$

If, therefore, in the case of the loop circuit in question, the branch containing it is made responsive to currents of a frequency 10 per cent different from that of the current which the loop is adjusted to exclude, n is 1.1 or 0.9 and the apparent resistance of the loop to currents of this frequency is 22.7 or 27.7 ohms, depending on whether the frequency of the current to be excluded is lower or higher, respectively, than the frequency of that to which the branch is attuned to respond.

If the current to be excluded is of the higher frequency, then the apparent reactance of the loop in the branch is an inductance reactance of 4,740 ohms, while if it be the lower frequency, the apparent reactance of the loop is a capacity reactance of 5,240 ohms. In place of the loop circuits shown in Fig. 3 loop circuits inductively coupled with the receiver branch may be used.

The arrangement of receiving apparatus shown in Fig. 4 shunts the currents from the neighboring transmitters out of the receiver by means of branch circuits separately made resonant, one to each of the frequencies generated at adjacent or nearby stations.[7]

The arrangement of Fig. 4 is typical of the induction balance circuit which can be used to render a receiver irresponsive to the currents generated by the transmitter at the same station. In this arrangement, the branch G O is separately tuned to the transmitter frequency, while the branches O D, P D and D G are separately tuned to the receiver's frequency. The device A is one having adjustable resistance, inductance, and capacity, and whose vector impedance may be made to correspond to any scalar multiple of the vector impedance of the line measured from the point P outward.

The transmitter and receiver branches O G and P D, respectively, are conjugate, the vector product impedance of the branches O P and D G being equal to the vector product of the vector impedance of the branch O D and that of the line. Bridges of this kind must be balanced both for the resistances and for the reactances of the branches.[8]

It is evident that when the conditions tending to produce interference in a receiver by a neighboring transmitter are exceptionally severe, the methods of freeing the receiver from such interference shown in Figs. 3 and 6 may be combined in the receiver without any difficulty. With a receiver so protected against "cross talk," the amount of energy of the current to be excluded may be millions of times greater than that of the current to be received and differ from the latter in frequency by but a few per cent without causing the least interference.

(To be continued.)

[6] The source of electromotive force must, of course, have its reactance neutralized by a separate condenser when it is used to tune a circuit from which it is to be removed after the tuning is completed.

[7] See U. S. Patents to Stone, Nos. 884,106, 884,107, 884,108, and 884,109.

[8] See "Electrical Papers" of Oliver Heaviside, vol. ii, pp. 33-38 and 366.

Annealing Steel in Alternating Magnetic Field

In a paper published in the *Physical Review*, H. Pender and R. L. Jones report on a series of experiments carried out by them on the annealing of steel in an alternating magnetic field. The possibility of important commercial application lends special interest to the results of this piece of research, which are summarized by the authors as follows:

1. It has been shown that the treatment of steel by a cyclicly varying magnetic field during its annealing results in a pronounced alteration of its hysteresis loop. The result is to increase largely the permeability at low and moderate inductions with a corresponding increase of the remanent magnetism. The coercive force and the losses are slightly decreased. The maximum value of the permeability was increased as much as 50 per cent in some cases.

2. The improvement of magnetic quality depends upon the maximum intensity of the force used in the magnetic treatment and shows an approach to a maximum or saturation value when the force is large.

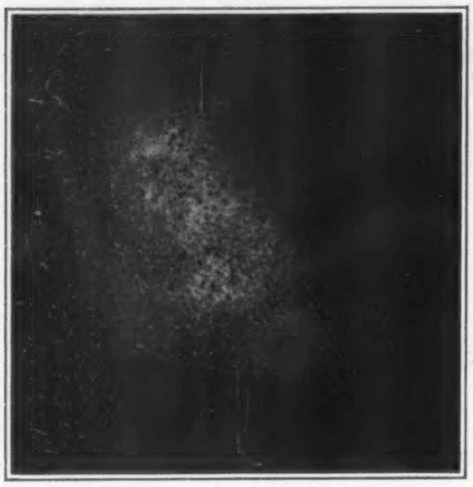
3. The best maximum temperature at which to apply the cyclic treatment has been identified with the critical point Ar_2, about 690 deg. Cent., on the iron and steel diagram, and through this fact and the evidence of the micrographic studies, it seems very probable that the good results obtained may be ascribed to a preservation of the fineness of the metallographic structure which steel possesses just after it has passed from the non-magnetic to the magnetic condition.

The above results are incomplete but exceedingly suggestive. They point the way to a new line of research on the treatment of steels for electrical purposes and possibly of those for other uses as well. None but magnetic qualities have been observed, but doubtless mechanical characteristics were also affected.

The possible commercial applications of magnetically annealed steel which suggest themselves are numerous. Many forms of direct current apparatus might be decreased in cost by its employment provided the requisite commercial conditions for the treatment could be obtained. Thus if the fields of direct-current generators and synchronous motors could be made of the material, the weight of iron could be decreased, though not in so large a proportion as the increase of permeability, together with a corresponding decrease in the mean length per turn of the winding and a consequent increase in copper efficiency. The power factor of transformers, induction motors, and alternating-current series motors could be improved, and the constancy of ratio of instrument transformers could be increased by employing magnetically annealed metal.

Automatic Deflated Tire Alarm

We read in *La Nature* that a French inventor, Mr. Bellan has devised a simple automatic alarm which warns the driver of an automobile of the deflation of a tire. In this way the trouble is noticed before it has led to further damage. The alarm is simply based on the fact that the rim of the wheel descends nearer the ground when the tire is flat. A small running wheel at the side of the main wheel then comes in contact with the ground and an electric contact is made, which sounds the alarm.



Oil Film Photographed Within Less Than One Second from Its Formation on Pure Water. Note the Holes at the Center and the Beads at the Edge.

Oil Films One Molecule Thick

A Direct Measurement of Molecular Dimensions by Simple Experiment

By Henri Deveaux

There is probably no feature more characteristic of the modern development of physics than our growing knowledge of the molecule, its dimensions, and its structure. We have had occasion repeatedly in the past to bring before our readers the work of J. J. Thomson, Perrin, and others in this field. The article which we reproduce here in extract from the Revue Générale des Sciences brings a new experimental method of determining directly the dimensions of the molecule. This method is of quite particular interest in that it is remarkably simple, the experiment being such as can be reproduced by any reasonably skilled person. Prof. Deveaux of the University of Bordeaux shows us how we can prepare a film of oil one molecule thick and by very simple means measure its dimensions. He finds that the thinnest film of oil which can be made has just exactly the thickness corresponding to one molecule as determined by various other methods. Any attempt to spread the film out further than this results simply in the rupture of the film.—EDITOR.

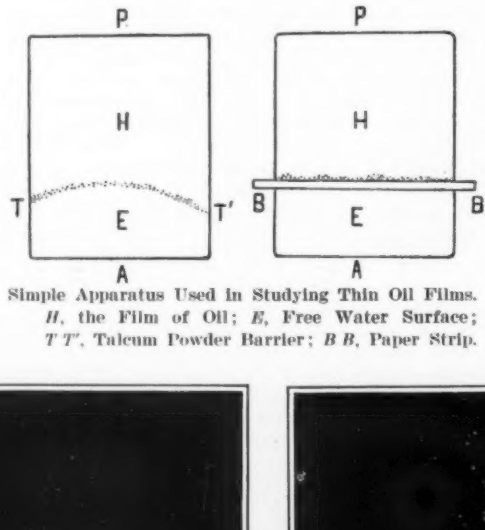
LORD RAYLEIGH in his admirable researches made about 1890, showed that the minimum quantity of oil spread upon water which would just arrest the motion of camphor particles, corresponded to a thickness of 1.6 micro-millimeters.[1]

Furthermore, he showed that there is a sudden change in the surface tension of oil when the film reaches about one half the thickness just indicated, namely 8/10 of a micro-milimeter, or, as Lord Raleigh puts it, about one micro-milimeter.

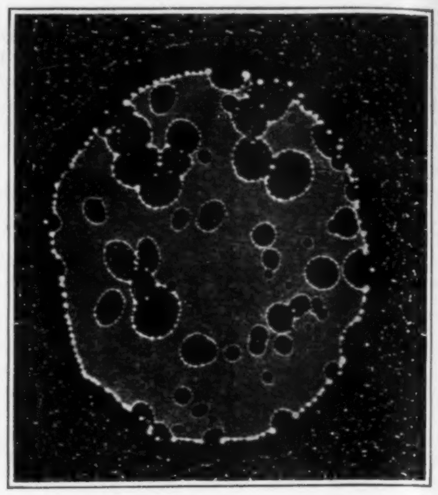
We can make measurements of greater accuracy by making use of a solution of known strength of oil in a volatile solvent. For this purpose I prepare a solution of oil in pure benzene, the best proportions to use are one cubic centimeter of oleine (trioleate of glycerine) to one thousand cubic centimeters of benzene, using a pipette which furnishes fifty drops of the solution for every one cubic centimeter. One drop therefore contains one fifty thousandth of a cubic centimeter (one eight hundred thousandth of a cubic inch) of oil. Two of these drops are allowed to fall upon the surface of water. They immediately spread over the entire surface and the benzine which evaporates almost instantly leaves behind it a residue of forty millionths of a cubic centimeter. Previous experiments have shown me that this quantity of oil is incapable of completely covering the surface of the water contained in the tray which I use (its surface area being 625 square centimeters). By blowing gently upon the surface I cause this oil film to travel to the farther end of the tray (a photographic developing tray is very suitable for this purpose) and I spread a very light veil of talcum powder upon the nearer end of the tray. The talcum thus falls upon the clear water surface *E* (see Figure). As I blow upon it, the talcum powder is carried forward, but it does not travel all the way along the tray. It is arrested along an invisible barrier, namely, the forward edge of the oil film.

[1] One micro-millimeter is one millionth of a millimeter, or about one twenty-five millionth of an inch.—EDITOR.

I next lay upon the clear water surface a paper band (see Figure) and then carefully move this forward, sweeping before it the talcum powder and straightening out the forward edge or barrier of the oil surface. By carefully moving the slip of paper to and fro, it is possible after a little experimenting to determine exactly, that is to say within a few millimeters, the extreme limit at which the film of oil shows a sudden change in surface tension. When this point is reached a measurement of the length of the film is taken. Its breadth is of course known once for all from the breadth of the tray used.



Simple Apparatus Used in Studying Thin Oil Films. *H*, the Film of Oil; *E*, Free Water Surface; *T T'*, Talcum Powder Barrier; *B B*, Paper Strip.



Film of Oleic Acid Upon Mercury. This Film Was Formed After a First Film Has Been Allowed to Reach the Bead-stage Upon the Same Mercury Surface.

In this way we obtain a measure of the mean surface occupied by the film of oil. In an experiment actually performed this surface was 262.71 square centimeters.

Now this surface was produced by two drops of oil solution. That is to say by forty millionths of a cubic centimeter of oil. The thickness of the film was therefore $\frac{V}{S} = \frac{40\times10^{6}}{363.71} = 1.10\,\mu\mu$ (micro-millimeters) with an uncertainty of about one in the second figure. The true value lies, say, between 1.04 and 1.15 micro-millimeters.

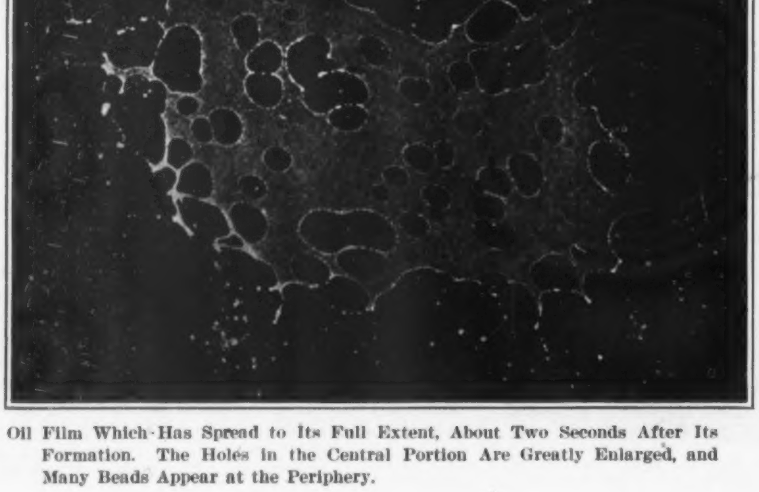
We may therefore say that the thinnest film of oil which can exist upon water is 1.1 millionth of a millimeter thick.

This thickness, almost identical with that mentioned by Lord Raleigh, is excessively small. We may obtain an idea of its magnitude by a simple comparison.

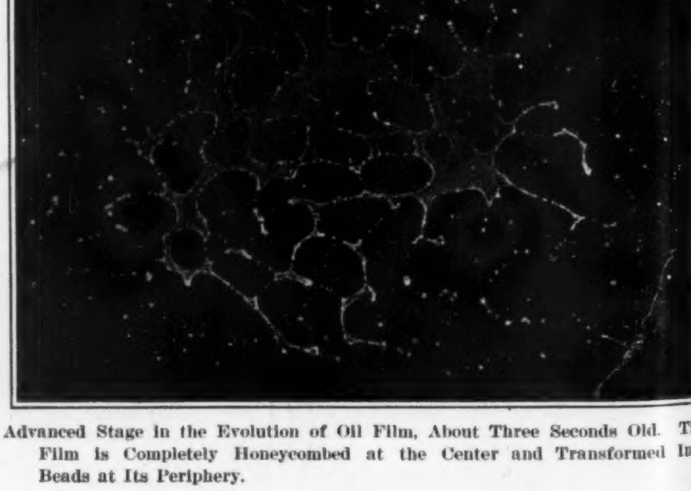
Let us imagine that a film of this thickness is spread over a geographical globe fifty centimeters in diameter (20 inches). Let us then imagine this globe increased in dimensions until it reaches the actual size of the earth. The oil film, magnified on the same scale, would reach a thickness of just about one inch, while the paper upon which the map of the globe might be supposed to be printed, and which in the original we will suppose to have been one tenth of a millimeter thick (about 1/250 of an inch) would now have a thickness of twenty-four kilometers (14½ miles).

COMPARISON WITH THE MOLECULAR DIMENSIONS AS DETERMINED BY OTHER MEASUREMENTS.

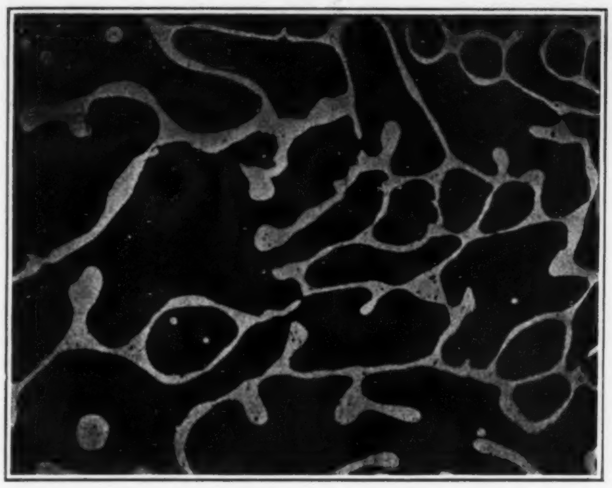
According to the molecular theory, the thinnest film



Oil Film Which Has Spread to Its Full Extent, About Two Seconds After Its Formation. The Holes in the Central Portion Are Greatly Enlarged, and Many Beads Appear at the Periphery.



Advanced Stage in the Evolution of Oil Film, About Three Seconds Old. The Film is Completely Honeycombed at the Center and Transformed Into Beads at Its Periphery.



Reticulum Formed by a Thick Film of Olive Oil Upon Water. Beads are Seen Here and There.

Final Stage in Its Evolution: The Entire Film Transformed Into Beads. Age, Ten to Fifteen Seconds.

which can exist of any body whatever, would evidently be one molecule thick.

Now, we have at the present day a number of independent and exact determinations of the so-called constant of Avogadro, which enables us to determine molecular dimensions. Let us therefore make this computation for oil, or more precisely for glycerin trioleate. Using first of all Perrin's result for Avogadro's constant, we find 1.13 micro-millimeters. The theoretical value of the molecular diameter of oil thus calculated is therefore practically identical with the 1.10 micro-millimeters which we found by experiment for the thickness of the thinnest oil film which we could prepare. The differences are merely hundredths of a micro-millimeter; that is to say hundredths of one millionth of a millimeter, or considerably less than one thousand millionth of an inch.

This leads clearly to the conclusion that the thinnest film of oil which we have been able to prepare is actually a layer one molecule thick.

If instead of placing merely one or two drops of the oil solution upon the sheet of water we allow a rather large drop, of, say, one to three hundredth of a cubic centimeter to fall upon the water, an interesting series of phenomena occurs.

As soon as the drop touches the water it spreads out and covers the entire surface. But the film thus formed is, comparatively speaking, very thick. It comprises several hundreds of molecules in thickness and is plainly visible owing to its reflecting power being greater than that of water. As a rule it presents beautiful interference colors, at least at some portion of its extent.

But this state of affairs is always transient, especially in the case of non-drying oil, if the water surface was thoroughly clean. The accompanying illustrations show some of the successive phases in the evolution of such a drop after it has been allowed to fall upon the surface of water. This evolution is completed in a period of ten to fifteen seconds, and, in fact, its principal phases are completed within the first three seconds. On the other hand, if the water has been previously oiled, the evolution of the drop is much more slow, and the drop then presents a circular boundary encircled by beads. Presently the brilliant oil film becomes pierced by circular blank patches, apparently holes in the film, through which the free surface of the water shows from below. These dark patches are greater or less in number according to the particular oil employed, and gradually increase in size, becoming at the same time encircled by a necklace of fine beads.

The first black patches to appear are situated near the edge of the film, that is to say, in its thinnest part. They very rapidly grow in size and presently begin to coalesce. Soon the more central patches undergo the same change so that presently the film of oil is finally transformed into a number of drops of varying sizes scattered over the surface of the water, which now appears once more clear, and with a uniformly dark surface.

It is evident, however, that the surface of the water is still covered between the globules or beads with a very fine film of oil; and the persistence of this final phase or condition demonstrates that this discontinuous distribution of the oil represents a practically stable equilibrium.

We must, therefore, distinguish between two phases in the evolution of the oil film, a transient phase and a stable phase which represents the terminal stage in the evolution of the system.

Experiment framed on a method resembling that described above with regard to the thinnest film of oil which can be prepared, have shown that in the case of the stable form just referred to, that is to say, the form consisting of a thin film over which are scattered beads, this thin film itself is again just about one molecule thick. It appears, therefore, that just as soon as the film of oil is allowed to contract from its maximum extension into a smaller area, what takes place is not that the film as a whole thickens, but that here and there the molecules gather into droplets, while the rest of the film remains one molecule thick.

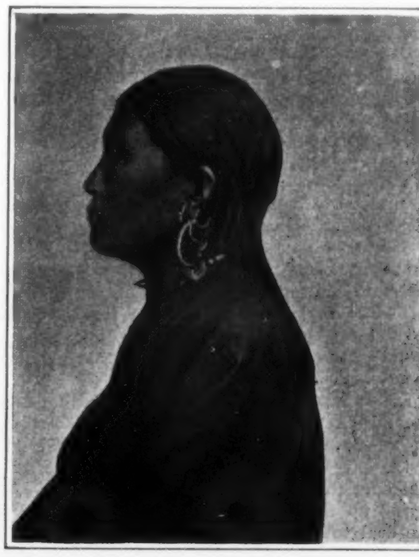
Whence Came the First American?

The Probable Ancestor of the Indian Found in Siberia

By Carl Hawes Butman

Siberian Type Closely Related to the American Indian.

An Algonquian Indian of the Piezan Tribe.



Resembles Indian in Physical and Mental Characters.

A PROBLEM of much interest, and of late a good deal before the public, is that of the origin of the American aborigine, in other words the native Indian. In this connection the recent investigations of Dr. Ales Hrdlicka, curator of physical anthropology, National Museum, tend to prove that the native American immigrated to this country in a post-glacial period, and is a representative of the overflow from northeastern Siberia, where he is closely related both mentally and physically to the yellow-brown peoples of Asia and Polynesia.

In a brief survey of this subject, two main questions at once confronted us: Did the American Indian originate here? Or has he come as an immigrant from the other continent? Evidence seems to be rather in favor of the second alternative, for most anthropologists agree that the original home of man was in Eurasia. If, now, we adopt this generally accepted theory, then the problem of manner and the period in which the populating of America was effected, presents itself, and we are forced to ask assistance of the other sciences, namely, geology, geography, comparative anatomy, culture history, biology, and many others.

At a joint session of the American Anthropological Association and Anthropological Division of the American Association for the Advancement of Science in Washington, an interesting discussion of the problems of the unity or plurality and the probable place of origin of the American aborigines was held and the report later published in the *American Anthropologist*. The reports of the various scientists taken all together seem to show that the Indian is an offspring of the Old World, although the time of his advent and the exact location of his former home was not definitely

agreed upon.

The views of the *Anthropologist* are most readily accepted in this matter since he is a student of the science of man, and as most American *savants* in this subject agree, it is only natural to grant their theory and await the proof. If their views concerning the Indian's origin are correct, there must be archeological remains and even a residue of his descendants in some out of the way corners of eastern and northeastern Siberia, where his ancestral stock lived in very early times. With this point in view the students of anthropology have been searching long and diligently in eastern Asia for these supposed forbears of our Indians, but while their researches have not been without interesting results, no absolute proof has been brought forth. Up to last year no anthropological investigation had been carried on to any great extent in eastern Asia, and consequently many points remained to be examined and reported on before the home of the physical stock from which the original American was derived could be permanently established.

While affairs were in this state, Dr. Hrdlicka was given an opportunity to visit a few of the most important parts of eastern Asia, and to ascertain what evidence could be found there relative to this subject, in order that he might lay out a plan for further anthropological and archeological research in those parts. Through the co-operation of the Smithsonian Institution and the Panama-California Exposition of San Diego, he was enabled to make a trip to certain sections of southeastern Siberia and northern Mongolia, including Urga, the capital of outer Mongolia, which incloses within its walls two large monasteries, and is constantly visited by a great number of natives from all parts of the country.

On May 16th, 1912, Dr. Hrdlicka sailed from New York on the steamer "Cedric" for London, whence he went to St. Petersburg and *via* the Transsiberian Railroad to Siberia. The Upper Yenisei region of Siberia was also visited and stops were made at Krasnoyarsk and Minusinsk. From Upper Yenisei he went to Irkutsk on Lake Baikal, and along the shores of the lake, as well as to other parts of Mongolia and Turkestan so far as the time and means of the expedition permitted. Leaving Siberia he visited Kiachta on the line between Russia and Mongolia, and then followed the road to Urga, whence he returned by way of the old caravan route to China proper and proceeded home *via* the Trans-siberian Railroad.

The Russian authorities and scientists extended many courtesies to the investigator, and he was enabled to make a very satisfactory trip in spite of the time limitations imposed upon him. Aside from collecting many specimens of bones and skulls, and obtaining statistics of measurements of the natives, he managed to visit several of the museums in the territory covered, inspecting the collections pertinent to his studies.

Among the interesting sites explored by Dr. Hrdlicka are the burial mounds or "kourgans" as they are called, located on the banks of the Yenisei and Selenga rivers and their tributaries, and along the streams of northern Mongolia, especially on the banks of the Kerulen. These "kourgans," which number thousands, are of inestimable value to the student in this work, on account of the fact that their date extends from modern times back to the stone age of these regions. They are but little excavated and practically untouched, for that matter, so that they offer a wonderful laboratory to the scientist who is given the privilege of opening them for study and comparison. At Minusinsk some investigation has already been made by Adrianov and his colleagues and by Prof. Talko-Hryncewitz of Krakow.

Oddly enough the date of the mounds is established quite as readily as if the date of construction were carved on a stone, for the different objects uncovered, be they of gold, copper, iron, bronze or stone, identify the origin of the particular mound from which they came as falling within definite time limits. Most of the "kourgans" appear to represent nearly recent times, corresponding to Ugrian or Turk or "Tartar" elements, as well as modern Mongolian. The skulls of the skeletons taken from these more recent mounds are of the brachycephalic type, short, somewhat spherical skulls, which occasionally closely resemble the same form of American crania, but the "kourgans" of earlier date, containing no metal objects, yield skulls resembling the dolichocephalic type, long and narrow, and much like American Indian skulls of this type. It is difficult to assert to just what race the older skeletons and skulls belong, and yet, on the banks of the lower Yenisei River, and in several other localities, living dolichocephalic types are not unusual, and such natives frequently bear a strong physical resemblance to our native Indians. Further burial spots are known to be located in caverns among the mountains bordering the Yenisei River, which, however, Dr. Hrdlicka was not able to investigate.

The most important part of the exploration and study was that pertaining to the living descendants of the old races. Among these people the investigator was fortunate enough to come into contact with representatives of many tribes from the banks of the Yenisei and Abacan rivers, also Buriats, Mongolians, Tibetans, Chinese and some Manchurians. He was happily present at a great religious ceremony at the Lamaist monasteries in the neighborhood of Urga, where seven thousand Mongolians from all parts of the country were in attendance.

Among all these tribes and clans there were individuals who apparently represent the older population, pre-Mongolian and pre-Chinese, and who belong partly to the brachycephalic type, though in a smaller extent to the dolichocephalic type. These men and women are practically identical with the American Indians of similar head form. The particular individuals are brown in color, with straight black hair, dark brown eyes and facial and bodily features which are strikingly like those of the native American. The men are practically beardless. Some of these people, if dressed in the costumes and regalia of an Indian, and placed among them, could not be distinguished from them. At least Dr. Hrdlicka states that there are no means at the disposal of the anthropologist by which to make such a distinction. It is not only in outward appearances that these natives of Siberia resemble the Indians, but mentally as well, and in numerous habits and customs which different environment and time seem not to have effaced.

During September, on his return trip, Dr. Hrdlicka stopped at Geneva and delivered a brief report of his investigation before the International Congress of Prehistoric Anthropology, then in session. This report, which has since been published by the Smithsonian Institution, was as follows:

"In conclusion, it may be said that from what he learned in eastern Asia, and weighing the evidence with due respect to other possible views, the writer feels justified in advancing the opinion that there exist today over large parts of eastern Siberia, and in Mongolia, Tibet, and other regions in that part of the world, numerous remains, which now form constituent parts of more modern tribes or nations, of a more ancient population (related in origin perhaps with the latest paleolithic European), which was physically identical with and in all probability gave rise to the American Indian.

"The writer is able to merely touch on the great subject thus approached. The task of learning the exact truth remains for the future. In relation to opportunities for further investigation, he has satisfied himself that the field for anthropological and archeological research in eastern Asia is vast, rich, to a large extent still virginal, and probably not excessively complicated. It is surely a field which calls for close attention not only on the part of European students of the Far East, but especially on the part of the American investigator who deals with the problems of the origin and immigration of the American Indian."

Pulverized Coal as a Fuel*

A Highly Economical Source of Heat

By H. R. Barnhurst

Coal properly pulverized and burned may be made to yield higher economic results than are attainable by any other means.

The requirements necessary to success, while simple, are absolute and must be obeyed.

First—The coal must be dried so that it contains not over 1 per cent of moisture.

Second—The coal must be pulverized to a high degree of fineness.

Third—It must be projected into a chamber hot enough to cause instant deflagration.

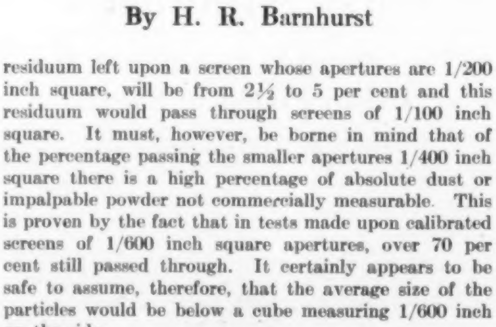
Fourth—It must be supplied with air sufficient to yield the oxygen necessary to burn the carbon of the coal at once to CO_2.

Taking up these requirements in order, the drying of the coal to a moisture content of not over 1 per cent is indispensable. Coal does not grind well if moisture in excess of this be present.

In burning coal the moisture, free or combined, must be disposed of either in the process of preparation or in the moment of combustion. In the latter case not only is the efficiency of the furnace lowered by the calorific investment in the superheated steam passing out as a product, but the temperature of the furnace is lowered materially. The drying of wet coal in the furnace itself, is doing this necessary part of the work in the most expensive place and at the cost of temperatures which may be essential to the industrial process of which high heat is a factor.

Fine Grinding.—With the best type of machines obtainable for this purpose, the coal and its contained impurities may readily be powdered to such a degree that under the screen tests 85 to 90 per cent will pass through apertures 1/400 inch square, while the total residuum left upon a screen whose apertures are 1/200 inch square, will be from 2½ to 5 per cent and this residuum would pass through screens of 1/100 inch square. It must, however, be borne in mind that of the percentage passing the smaller apertures 1/400 inch square there is a high percentage of absolute dust or impalpable powder not commercially measurable. This is proven by the fact that in tests made upon calibrated screens of 1/600 inch square apertures, over 70 per cent still passed through. It certainly appears to be safe to assume, therefore, that the average size of the particles would be below a cube measuring 1/600 inch on the side.

It may be interesting, therefore, to state that the total numbers of particles resulting from the powdering of 1 cubic inch of coal to the dimensions given would



Arrangement of Plant for Using Pulverized Coal as Fuel.

yield 216,000,000 grains of dust. Simple calculation on this basis shows that while a cubic inch of coal exposes 6 square inches for the absorption and liberation of heat, the surface exposed for the same purposes by the powdered coal is 25 square feet. Inasmuch as no fuel burns until it is heated to a temperature at which it develops more heat than it receives, the advantage of this enormous absorbing and delivering surface is apparent. The result of this is shown in the clearness and uniformity of the flame produced. Where coarse particles are permitted to enter the furnace, the distinct sparkles are apparent. These larger particles are carried beyond the region of oxygen supply and are for this reason not fully burned.

Third.—While coal ignites freely, in a hot chamber, this ignition means the absorption of heat from somewhere, and if the coal rapidly projected by air does not develop its heat near the point of ignition, means must be devised to maintain the heat necessary for ignition where it is needed, i. e., at the first entrance of the coal into the furnace. It is apparent, therefore, that giving the fuel too great velocity upon entrance is not good practice.

Considering the fourth requirement along with the third we would say that some singular errors and misconceptions have attended the practices of many users of powdered coal. More particularly do we refer to the use of large fans to supply the air necessary for the projection of the fuel, where the air nozzle has been reduced from 16 inches or 18 inches diameter to 4 or 5 inches at the jet in the expectation that all of the air in the 16-inch or 18-inch pipe would be hurried through the 4 or 5-inch nozzle if not a smaller one. The futility of this is apparent.

To describe the operation in greater detail, the coal is received in a bin over the feeders. Its

* Reproduced from *Metallurgical and Chemical Engineering.*

weight is about 38 pounds per cubic foot when loose in the bin. Settling awhile brings the weight to about 45 pounds per cubic foot by displacing the entrained air. Across the bottom of this bin and within a pipe extending horizontally from it is a double-flight worm or feed screw. This double-flight screw resists the tendency of the light coal to flow of itself along the feed pipe. This screw extends over a flanged pipe-cross into which the fuel is delivered. The rear end of the screw is supported by a bearing in a flange on the side of the bin near the bottom, the shaft projecting to receive a driving pulley or chain sprocket. The delivery end of the screw shaft is supported by a bearing in the cover of the horizontal opening of the flanged pipe-cross. The top opening of the cross is uncovered to permit the air to draw down with the falling fuel. This fuel dispersed in the air so drawn in, descends a vertical pipe attached to the lower opening of the cross, the pipe being long enough to be within the funnel or injection pipe. At the bottom of the funnel is a diagonal plate upon which the fuel falls. The plate is tight against the air pipe up the current and flared open on the side, toward the furnace down the current and takes up about one fourth the diameter of the pipe. This forms at this point a "vena contracta" producing a suction in the funnel, drawing in through it, supplementary air with the fuel. The fuel spraying upon this plate mixes very thoroughly with the air from the fan, the eddy currents caused by it, assisting very materially its dispersal through the main column of air supplied by the fan.

The admission funnel should be far enough from the furnace to permit this mixture to be thorough. Too high pressures defeat this somewhat, as well as tending to project the fuel too far into the furnace before flashing. As soon as this fuel cloud begins to absorb the heat of the chamber into which it passes, a rapid expansion of the air takes place, separating the particles of fuel in suspension, in the proportions of the absolute temperatures to the temperature of the initial air. It is a matter of discussion whether the best results are obtainable by a delivery of all the air found necessary for combustion by the feed pipe together with the percentage of excess air found to produce the best results, or to use a smaller quantity of air in the feed pipe and look for the further supply from other openings.

Good practice would seem to point to absolute control of air by the fan and its gates, and the fuel by the varied speed of the feed screw. The furnace should have a good natural draft to a chimney controlled by a damper. It must be remembered that perfect combustion of one pound of carbon demands 2.2/3 pounds of oxygen. This is contained in 11.6 pounds of air or about 154 cubic feet; should less than this be supplied a proportionate amount of fuel will be burned to CO with a loss of two thirds of its initial efficiency, a part of which may be regained by contact with heated oxygen, or it may pass on and burn in the chimney, doing no good if the heated oxygen is brought there in first contact with it. If the oxygen is not heated sufficiently smoke results and full heat undeveloped.

The greater the volatile constituents of the coal the more readily will it deflagrate, as these gases distil from the fuel and ignite at a temperature lower than that required for the carbon itself. Their need for oxygen is, however, greater per pound of fuel (or gases) than that of carbon, and is proportional to the heat evolved. Their average value is in heat units nearly 50 per cent more than that of carbon.

The temperatures attainable with pulverized coal are very high, so high that excess air is commonly admitted in proportions ranging between 50 and 100 per cent. This will be shown by the following table based upon the perfect theoretical combustion of carbon with proportion of air given:

1 lb. carbon with 11.6 lb. air	Normal.	4859°F.
1 lb. carbon with 12.76 lb. air	10 per cent excess.	4448°F.
1 lb. carbon with 13.92 lb. air	20 per cent excess.	4102°F.
1 lb. carbon with 15.08 lb. air	30 per cent excess.	3807°F.
1 lb. carbon with 16.24 lb. air	40 per cent excess.	3550°F.
1 lb. carbon with 17.40 lb. air	50 per cent excess.	3326°F.
1 lb. carbon with 18.56 lb. air	60 per cent excess.	3129°F.
1 lb. carbon with 19.72 lb. air	70 per cent excess.	2954°F.
1 lb. carbon with 20.88 lb. air	80 per cent excess.	2797°F.
1 lb. carbon with 22.04 lb. air	90 per cent excess.	2656°F.
1 lb. carbon with 23.20 lb. air	100 per cent excess.	2529°F.

In practice the furnace tender speedily becomes educated to the point of judging whether a fire is hot enough by its color and by the length of the flame. The more perfect the conditions the shorter and whiter the flame will be.

The pulverized coal introduces very effectively the element of time into the equation. Given a pound of fuel with say 15,000 heat units, these may all be developed by slow combustion at low temperature, or by burning the fuel in pulverized form, quick combustion gives high temperature. The same quantity of heat developed in both cases, but in one instance in a minute and in the other half an hour.

The influence of preheated air upon the economy of the burning of any fuel resolves itself into ascertaining the quantity of fuel which would be necessary to bring the air to the preheated temperature plus the heating of the excess air also to that temperature. Except as a means of transporting heat excess air has no effect in the furnace as far as the fuel combustion is affected. This preheating to be of any economical value must be obtained from heat which would else be wasted. To heat all the primary air necessary to combustion and 50 per cent excess air to a temperature of 1,000 degrees in excess of the surrounding temperatures would show a saving of some 4,100 heat units or nearly 30 per cent of the fuel value. But few of the industries, however, outside of the metallurgical arts permit the waste heat to pass off at such temperatures and volume as to be available. The regenerative checker-work of open-hearth steel furnaces is the best example of success in this preheating.

In this case it has been a necessity to boost the temperature in this way, because the gases from gas producers burned cold, would not give the temperatures necessary for the work to be done.

We may say that four heat units per degree would represent the saving achieved per pound of fuel fired with 50 per cent excess air by heating all the air admitted to the furnace. The measure of efficiency is dependent upon the loss finally carried away in the rejected gases. In the case of regenerative furnaces this may be lower than in furnaces not equipped with regenerating checker-work, but if to the percentage of loss with regeneratives be added the losses in the gas producers, the pulverized coal directly fired will afford the greater economy of operation.

With the means at hand of obtaining quickly and safely heat of greater intensity than by the use of coal upon grates or in producers, it would appear to render practicable further steps in many of the arts hitherto restricted by the limitations of furnaces at command.

The fear of explosion of coal need not enter into consideration. Coal lying in a bin or conveyor does not explode. It is only when mixed with air or supported by air currents that coal will "puff." In burning it, therefore, we do not mix the coal and air until just as it enters the furnace at high velocity. Against this column of inrushing air and coal the puff cannot take place.

The air is introduced before the coal is turned on, and the coal is shut off before the air. Only by introducing coal faster than it can burn will an explosion occur and then the effect is trifling. It is the gas produced and not the coal that causes this. It wants oxygen and comes outside to get it.

The presence of impurities in the fuel has not much effect. Of course, only combustibles will burn; the incombustibles are inert and do not affect the operation of the furnace. Their effect is in the lessened results from a dollar's worth of fuel negatived by a goodly percentage of waste substance. The writer has burned effectively fuel in which analysis showed 52 per cent of ash. Let us reiterate the conditions: *Dry coal, fine grinding, hot chamber or fire box, proper air supply.*

An important part of the subject must not be overlooked. The durability of the furnace is, of course, vitally essential. In the metallurgical arts when extreme heat is an essential part of the operation, care must be taken to avoid destroying the furnace by its own operation. This is not difficult. Much of the troubles have come from the gases impinging upon the furnace walls at points where change of direction of gas travel is necessary, and from too high velocity of gases due to contracted ports.

If the utilized heat is largely absorbed from the gases by the charge, the waste gases will be proportionately less active in scouring the brickwork. In almost any construction except perhaps a rotary kiln it is found necessary to change the direction of the gases in their progress toward the flue. This change of direction causes the gases to impinge upon the diverting bricks with an energy proportional to their velocity. The brick at these points can be fully protected by a system of water-cooled pipes embedded in the walls. The brick may frit somewhat until the area of protection is reached, at which further progress is arrested.

The surprisingly small amount of water which it has been found necessary to introduce, maintaining the outlet below 200 deg. Fahr. proves that the cooling effect is limited to a prevention of cumulative action and is not perceptibly a drawback upon efficiency. Of course, the piping must be so arranged that no air or steam pockets shall exist and that the circulation will be proportional to the heat stimulus. One other point and we will conclude. The pulverized coal furnace has no ups and downs. There is no thick fire or thin fire, fresh coal or old coal to insure fluctuations.

The furnace can be always kept at its best working point and so kept it will be heated equally all over. Of course, a large charge of metal to be heated will by its very volume absorb heat rapidly causing a fall in waste gas temperature and possibly a little smoke at first. This is in the nature of things, but the extremely effective conditions quickly bring the charge to a point where the chill is not sufficient to affect combustion and high temperatures come again and smoke disappears. If the work to be done is constant, there is no reason why high conditions may not be uniformly maintained by proper construction and operation.

We believe the subject has been mastered to a point beyond the experimental stage where the full benefits of high efficiency may be confidently relied upon in this beautiful method of burning coal. As before mentioned, the quality of the coal is not with this method of supreme importance. Indeed, its great value in the developments of the future may lie in the efficiencies obtainable from low-class or refractory fuels hitherto unavailable.

How Much Bread Will a Given Quantity of Flour Make?

Few people, other than the bakers, have even the most remote idea of how much bread a barrel or any other quantity of flour should yield, or how much more one brand will make than another. This is a much more important matter than the mere question of whiteness of the bread, or even of its real or apparent lightness. For some brands and lots of flour are much drier than other kinds, and will absorb much more water to bring them to the same degree of dryness as other brands, or other lots of the same brand. Further—and what is of much more importance—the quality of gluten contained in the flour, which is the more nourishing of the two principal constituents, determines much more largely than does the starch, the amount of water that the flour will take up.

The best should be the cheapest, if the amount of bread made per pound under the same conditions is proportionately greater than the price demanded therefor.

I happen to have on hand data concerning two well-known American brands, namely, "Gold Coin" and "Seal of Minnesota." From the former, a good baker or housewife can make about 345 pounds of dough per barrel of 196 pounds of flour, that is, 176 pounds of dough per 100 pounds of flour. Of the second brand, the figures at my disposition show 168 pounds of baked bread per 100 pounds of flour. It is probable that many bakers do not do so well as this, and possible that some do even better.

A Simple Rule for Certain Trigonometric Identities

By L. H. Rice

While looking over identities recently, I was struck with the advantage of using a certain set of equations, and therefore with the need for some simple way of memorizing them. These equations are:

$$\sin x = \cos x \tan x = \cos x/\cot x = \tan x/\sec x,$$
$$\cos x = \cot x \sin x = \cot x/\csc x = \sin x/\tan x,$$
$$\tan x = \sin x \sec x = \sin x/\cos x = \sec x/\csc x,$$
$$\cot x = \csc x \cos x = \csc x/\sec x = \cos x/\sin x,$$
$$\sec x = \tan x \csc x = \tan x/\sin x = \csc x/\cot x,$$
$$\csc x = \sec x \cot x = \sec x/\tan x = \cot x/\cos x.$$

Some arrangement of the names of the functions, it seemed, might be devised which would afford a mnemonic; and the functions did, in the end, prove tractable, giving the following diagram.

$\tan x$

$\sin x$ $\sec x$

$\cos x$ $\csc x$

$\cot x$

Take any function in this circle of functions and read the two adjacent functions as a product equal to that function. Or, read one of these adjacent functions *over* the next one beyond it as a quotient equal to the selected function. Or, read the other of the adjacent functions *over* the next one beyond that as another quotient equal to the selected function.

In proving identities, the reverse process comes often into play. The product of two functions being seen to consist of two functions that are separated by one function in the circle, that one is substituted for the product. Or, a quotient being seen to consist of two functions that are successive functions in the circle, the equivalent single function on the proper side of them is substituted.

It should be noted also that each function stands diametrically opposite its reciprocal.—*The Mathematics Teacher.*

The Coloration of Butterflies*

Some Striking Examples of Protective Mimicry

By Rev. F. Bennett, M. A., Oxon.

Fig. 1.—1, Large Cabbage White; 2, South European Brimstone; 3, Foreign Species; 4, Small Copper; 5, Foreign Species; 6, Foreign Orange Tip.

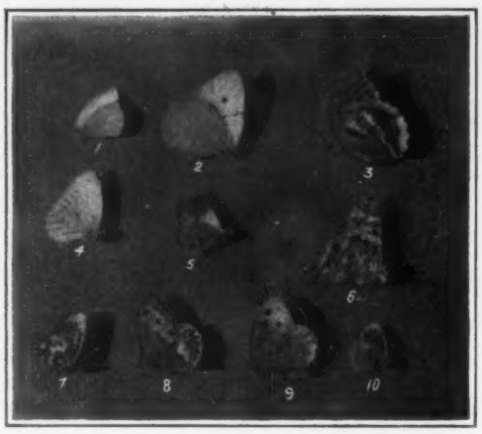


Fig. 2.—1 and 4, Green-veined White; 2, Small Cabbage White; 3, Silver-washed Fritillary; 5, Orange Tip; 6, Painted Lady; 7, Pearl-bordered Fritillary; 8 and 9, Grayling; 10, Small Heath.

Fig. 3.—Leaf Butterfly.

In the case of many butterflies, when one of them alights, and intends, not merely to sun himself or display his beauties to an admiring sweetheart, but to rest for some time, he first folds his wings together closely back to back, and then draws his fore wings downward in such a manner that they are, as completely as possible, covered by the hind wings; and it is obvious to any observer that in very many cases the underside of the hind wings is the part so colored in various ways as to resemble the surroundings and thus conceal the creature from its enemies.

I say "as completely as possible;" for the difference in the shapes of the fore wings and hind wings prevents this covering from being quite complete. In almost all cases the hind wing is rounded, while the fore wing is more or less triangular in shape and ends in a point, and thus the tip of the fore wing remains uncovered and visible.

Now the beautiful detail which I propose to illustrate is this: That the uncovered portion of the underside of the fore wing, repeats in a great number of instances the pattern and coloring of the under surface of the hind wing and thus carries out to perfection the concealment; while the remainder of the under-surface of the fore wing, covered when at rest by the hind wing, has often quite different coloring and is in many cases of most brilliant and conspicuous hues.

As I first observed this detail in the "Orange Tip" (I prefer the ordinary English names to the scientific ones, as each butterfly has such a number of systematic synonyms), I will give that charming little herald of spring the first place in the illustrations (see Fig. 4), though it is not perhaps the best of them.

No one will, after looking at the picture, doubt for a moment the use of the peculiar pattern on the underside of the hind wing. The butterfly is settled on an umbel of wild chervil and any one who wants a specimen of an Orange Tip has only to wait in a lane full of that plant and he will soon find one coming along, if it be May or June, though he may look in vain for one in the adjoining fields.

The resemblance is so complete that the butterfly in the midst of the umbel can hardly be discovered at all, and if the photograph could have been done in colors, the concealment would only have been more completely shown; the white parts of the wing representing the flowers, and the green parts representing the stalks, involucres and other green parts of the plant as well as the background of grass or hedge in the distance. The conspicuousness of the specimen whose wings are not drawn together proves the point to perfection.

Now the pattern (we might call it *the design*) on the hind wing which so completely conceals the resting Orange Tip is, it will be seen, continued at the tip of the fore wing and this continuation of the pattern is precisely outlined by the very curve which the end of the hind wing makes. They fit exactly! But the orange spot is completely concealed.

But there is more than this, for it will be observed that the front margin and even the thin, sharp edge of the fore wings (this edge being often somewhat rounded) have markings of the same type, so that, looked at *in front*, the protective resemblance to the flower is continued, in place of a white line which would otherwise appear and be dangerous, so minute are Nature's details in this matter.

But there is yet even more. It will be seen on examination that the pattern on the tip of the fore wing is somewhat run into lines (as may be seen in Fig. 2, No. 5). This repeats a tendency to the same thing at the margin of the hind wing; and it thus imitates in connection with the background of green, and just at the right place, the appearance which the *edges* of the umbel present.

The completeness and exactness of the continuation of the pattern are even more clearly shown in the butterfly (Fig. 1, No. 6) a foreign relative, I think, of our Orange Tip. In this the imitation of the pattern on the hind wings is much more exact, as will be easily seen.

The *economy* of Nature is wonderfully illustrated in these cases, since there is precisely as much as needed of the pattern on the fore wings and no more, the curves fitting so truly.

Just the same sort of pattern and its repetition are seen in the "Bath White" (Fig. 5).

A brief review of the illustrations will sufficiently demonstrate the use of this arrangement of color and markings.

Fig. 1, No. 1, and Fig. 2, No. 2, show the large and small Cabbage Whites. In both the greenish-yellow of the hind wing is repeated at the tip of the fore wing. The color is close to that of the cabbage flower, but it more closely still resembles that of a dead piece of cabbage leaf, which, when faded, takes exactly this color.

It may be noticed that a "small white" will sometimes place itself *sideways*, so that its wings lie flat on the leaf. The same is true of "Meadow Browns," which sometimes thus place themselves on the ground. Such a position would aid in the concealment and (in the absence of any other explanation of this curious custom) would seem to be adopted for that reason.

Fig. 1, No. 2, is a South European form of the "Brimstone" and the greenish-yellow of the hind wing is repeated at the tip and along the front margin of the fore wing, while the folding conceals a brilliant patch of orange. This repetition along the front margin would be useful while the folding of the fore wing behind the hind wing was in progress, or was incomplete.

Fig. 1, No. 3, is a foreign butterfly in which the silver spots and olive green of the underside of the hind wings are repeated at the tip of the fore wing, while the rest of the fore wing, concealed when at rest, is of a bright red-brick color with black spots, and a conspicuous white bar.

Fig. 1, No. 4, is the "Small Copper," in which the gray of the hind wing is continued at the tip of the fore wing, and the brilliant color and spots hidden by the folding over.

Fig. 1, No. 5: Underside of a foreign butterfly. The coloration of the hind wing, a dusky brown, is repeated at the tip, and a brilliant yellow bar concealed.

Fig. 2, Nos. 1 and 4, are "Green-veined Whites." It is well known that these vary very much, so that they have been divided by some authors into several species, and the curious thing is that, as the colors and the markings of the hind wing vary, so precisely do the colors and marking vary at the tip of the fore wing.

Fig. 2, No. 3, is the "Silver-washed Fritillary," in which the green of the hind wings is repeated at the tip with sometimes a little of the silver. In other fritillaries, more or less of the same arrangement will be found, and in the "Pearl-bordered Fritillary" (see Fig. 2, No. 7), the brick red patches which are on the hind wing are more or less repeated, with part of the paler yellow at the tip of the fore wing and only there. I do not know what this red brick may represent, but it is evident that to have a patch of a different color

* Reproduced from *Knowledge*.

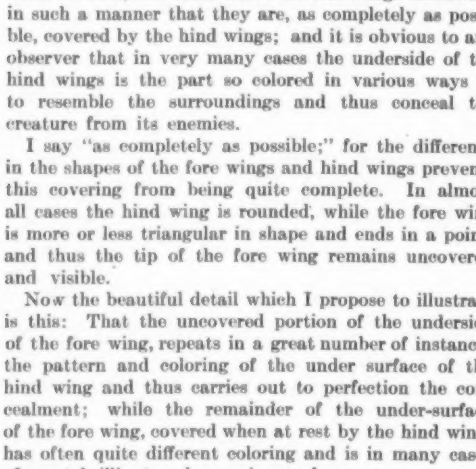


Fig. 4.—Orange Tip Butterflies on Wild Chervil.

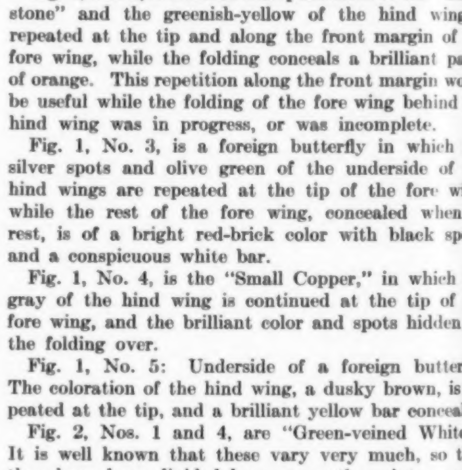


Fig. 5.—Bath White Butterflies.

at the tip of the fore wing would render the creature much more conspicuous.

Fig. 2, No. 6, is the "Painted Lady," in which the brown and gray of the fore wings are repeated at the tip of the fore wing, while the brilliant pink and yellow are concealed.

Fig. 2, Nos. 8 and 9, are two specimens of the "Grayling" or "Rock-eyed Underwing." The markings of the hind wing vary a good deal and in exactly the same manner do the markings of the fore wing vary to correspond, both at the tip and along the front margin.

Fig. 2, No. 10, is the common little butterfly variously called "Small Heath," and "Least Meadow Brown." In this, when closed, the brown and gray are repeated at the tip, while the yellow and orange and the eye spot of the fore wing are concealed.

Fig. 6 is the "Marbled White," in which the pale and thin-lined pattern of the hind wing is repeated at the tip of the fore wing, while the darker coloring of the fore wing is concealed. This is more obvious in the American form, which has a brown-lined pattern on the hind wing exactly repeated at the tip of the fore wing. I do not know what the markings in the American species may represent, but it may not be a wild conjecture that the object of the pattern in the English butterfly is indicated by the surroundings which I have given it, and that it conceals the creature by imitating the dead panicles of grass which abound in those dry places near woods where the butterfly is so often to be found, and on which it frequently settles.

We do not see the full force of any argument till we look at it (so to speak) from the opposite side; and this detail in protective coloration is clearly brought out by the cases where it is not needed. Contrast, for example, the underside of the wings of the "Comma," "Large Tortoise-shell," "Peacock," where the protective coloring is spread over the whole of *both* hind wings, with the repetition of the hind wing pattern in "Small Tortoise-shell," "Red Admiral," and so on.

It is curious that in *Anosia menippe* Hübner, a butterfly which is now sometimes caught in England and which is said to be protected by a nasty taste, the paler color of the hind wings is repeated in a patch at the tip of the fore wings, while the color of the rest of the fore wings resembles that on the upper surface. The detail seems to indicate that the bright brownish-yellow may not in these cases be *warning* as had been supposed. On that supposition it would seem difficult to find a reason (and a reason *must* exist) for this curious bit of repetition.

Figs. 3 and 7 are two species of the leaf butterflies whose likeness to dead leaves is now so familiar to us all. These, of course, do not fold the fore wing behind the hind wing, and there is, therefore, no reason for any repetition of the hind wing pattern. The tip merely displays a little imitation of a fungus.

The head of the insect is placed between the wings and hidden, when it is at rest. This puts out of sight the conspicuous eye, which would perhaps tell a tale, so complete are the arrangements for concealment.

An interesting point here occurs; most dead leaves hang down; do the Kallimas take that position or do the leaves of the trees on which they rest retain the upright position when dead? I have not seen this noticed by the authors on the subject.

The Nyctalemon Moth of the Andaman Islands evidently represents a dead leaf, as it has an imitation of a midrib throwing an imitation shadow on one side, and has also a tail to represent the stalk. But most moths appear to rely on the upper surface of their wings for concealment. Many of them, as the so-called "Underwings," have their brilliant colors on the upper surface of the hind wings and conceal these, when they are resting, with the fore wings, which are protectively colored. This, no doubt, applies to

Fig. 6.—Marbled White Butterflies on Dead Panicles of Grass.

some butterflies whose wings are colored in the same way.

The "Skippers" form a group half-way between the Moths and the Butterflies. Our "Dingy Skipper" is said to rest with the wings folded over its back in the exact position of a noctuid. Now the "Dingy Skipper"

Fig. 7.—Leaf Butterfly, *Kallima*.

shows no sign of any repetition at the tip of the fore wing of any special color on the hind wing; but the "Large" and the "Small" Skippers both show the usual repetition of the hind wing coloring. How *they* rest I am not certain.

Every one will, I am sure, agree that sufficient proof has been given of the existence of this curious and minute arrangement of Nature for the protection of these little creatures; but it is in all such cases to be noticed that there is often some little imperfection in the work of protection. It seems as if Nature in Evolution was sometimes actuated by two or more contradictory plans, which she has to harmonize as best she can. There is the tendency to some protective resemblance, but there is also the tendency to brilliance of color or design for the purpose of recognition by or attraction of the opposite sex; and, lastly, there seems to be a real tendency to develop color in special places, as, for example, along the nervures of Lepidoptera, as in the "Green-veined White," "Black-veined White," and so on, a tendency which is also, no doubt, responsible for the frequent coincidence of markings on both sides of the wings, as in the "Brimstone," "Clouded Yellow," "Apollo," and so on.

Such tendencies are obviously opposing ones; and one is often lost in admiration at the wonderful methods by which Nature has reconciled them, often producing the most perfect protection and at the same time the greatest beauty. It is conceivable also that in such a case as that of *Danais chrysippus* the upper side of the wings may have warning colors while the under side, where the yellow of the hind wings is repeated at the tip of the fore wings, as in *Anosia menippe*, may be protective, to guard against inexperienced enemies who do not know that they are unpalatable for eating, and so would kill or injure them in mistake, just as cats kill innumerable shrews which afterward they will not eat.

This detail in coloring shows with what minuteness Nature carries out the plan of protective coloration and resemblance, and how small a piece of detail gives some advantage in the struggle for escape; for otherwise this little bit of coloring would not have continued. In further illustration of the minuteness observe the delicate imitation of a tear in the wing of *Kallima* (see Fig. 7). Only with a magnifying glass can one see that the tear is not real, and that the wing is perfect. The effect is produced by alternate black and white markings.

The success of the protective coloring is frequently forced on the attention of the butterfly hunter, who finds that the insect he has been pursuing has disappeared from his view though he knows and sees, just too late, that it has been all the while within a very small plot of ground.

There is also another point of view which I have not seen brought forward, as to the success of this sort of protection. It is this: That an animal *has no time to waste* in examining objects which at closer quarters might (though a little *suspicious*) turn out to be really twigs or leaves; and thus a very imperfect resemblance (to *our* eyes who have plenty of leisure for the examination) would often be sufficient, and would be preserved till in process of time a more and more perfect resemblance was evolved. If one watches a bird supplying its ravenous nestlings one can easily see that it has to do the work at full speed.

If we sometimes thus placed ourselves in the position of animals, and by imagination "identified our minds" (in E. A. Poe's phrase) with theirs for awhile, we should very often comprehend Nature better and discover more of her secrets.

The Evidence That Sodium Belongs to a Radioactive Series of Elements*

By F. C. Brown

Campbell and Wood[1] could not detect in the compounds of sodium any activity that was definitely greater than that common to all matter and certainly no activity one thousandth as great as that of potassium. If, therefore, sodium belongs to a radioactive series of elements, it of itself must be undergoing disintegration and at the same time be inactive so far as measurable ionizing radiations are concerned, or sodium must be a relatively inactive product resulting from a radioactive parent. If the former is true then sodium left at rest a long period of time should diminish in amount. But if the latter presumption is true, sodium should in time form from one or more elements in appreciable quantities.

For evidence as to these presumptions the facts of geo-chemistry are used and it is found that two separate sets of facts favor the hypothesis that sodium has been accumulating radioactively over the land during geologic history. First an investigation of the sodium carried to the ocean by the rivers annually, and also an investigation of the total sodium content of the ocean, seems to show that the age of the ocean and of the earth is probably not more than 75,000,000 years old. Joly[2] and also F. W. Clarke[3] after a careful consideration of the possible sources of error deduce these figures. On the other hand if the age is based on the amounts of lead and helium associated with uranium in minerals, we find that the age is upward of a billion years. Thus far the fact seems to be that there is not as much sodium in the ocean as expected. The apparently sufficient explanation is that sodium has been accumulating radioactively over the land but not so over the ocean. Thus the rivers formerly should not have carried as much sodium as they carry at the present day.

An investigation of a second set of facts also makes it convenient to put forth the hypothesis of the radioactive accumulation of sodium over the land areas. If we compare the annual additions of sodium and chlorine by the rivers, it is found that more sodium than chlorine is carried to the ocean. While an examination of the contents of the ocean water reveals much more chlorine than sodium, these two elements are compared because both are soluble in all compounds and neither is deposited in appreciable quantities in the ocean sediments. Of course this comparison only indicates that sodium has accumulated more rapidly than chlorine. So far as the argument is concerned the element chlorine itself may also have accumulated radioactively in past ages.

No other common explanation has been offered for the two distinct sets of comparative data here used. It would seem therefore worth while to make a search for the possible parentage of sodium. The parent or parents should commonly exist over the land areas, and should in all compounds be relatively insoluble in water. If, however, the parent substance has become extinct or almost extinct this search would be futile.

* Abstract of a paper presented at the Evanston meeting of the Physical Society, November 30th, 1912, published in the *Physical Review*.

[1] Proc. Camb. Phil. Soc., 14, p. 15.

[2] Phil. Mag., 6, 22, p. 357, 1911.

[3] The Data of Geo-Chemistry, second edition, *Bulletin* 491, N. S. G. S.

Correspondence

[The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.]

Preparing Tables of Cubes, etc.

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

A study of Mr. A. W. Weeden's device for preparing a table of cubes of numbers by simple addition, published in the SCIENTIFIC AMERICAN SUPPLEMENT of May 3d, indicates that a table may be prepared for finding, in a similar manner, any power of any series of numbers in Arithmetical Progression. The method is exemplified for (1) cubes of the natural numbers, (2) cubes of the odd numbers, and (3) fifth powers of the natural numbers.

(1) Cubes of the natural numbers:

48 217 729 $=9^3$
54 271 1,000 $=10^3$
60 331 1,331 $=11^3$
66 397 1,728 $=12^3$

(2) Cubes of the odd numbers:

168 386 729 $=9^3$
216 602 1,331 $=11^3$
264 866 2,197 $=13^3$
312 1,178 3,375 $=15^3$

(3) Fifth powers of the natural numbers:

240 390 570 781 1,024 $=4^5$
360 750 1,320 2,101 3,125 $=5^5$
480 1,230 2,550 4,651 7,776 $=6^5$
600 1,830 4,380 9,031 16,807 $=7^5$

For facility of addition the numbers have been arranged in diagonal lines. Every number, in each diagonal line but the first, is the sum of the two immediately preceding it in the column to the left of it. It will be observed that the diagonal line at the extreme left is composed, in each instance, of a series of numbers in arithmetical progression.

For practical purposes a table dealing with the powers of the odd numbers only, as in (2), is all that is necessary, as the powers of the even numbers may be calculated quite readily from those of their halves.

Hamilton, Ont. J. G. WITTON.

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

Your correspondent, Mr. Arthur W. Weeden, whose letter entitled "A Simple Method of Preparing Tables of Cubes" appears in your issue for May 3d, has simply availed himself of the fact that the cubes of consecutive numbers form what is called in Elementary Algebra a differential series. The cube of any number may be found by applying the well-known formula for the *n*th term of the series:

1 8 27 64 125.......
7 19 37 61
12 18 24
6 6

Hartford, Conn. F. S. LUTHER.

The Gear Engine Cycle

To the Editor of the SCIENTIFIC AMERICAN SUPPLEMENT:

When claims of importance to the mechanical world are made in connection with an invention such as the gear engine, described in a recent issue of the SCIENTIFIC AMERICAN, technical men demand a more thorough explanation than that popularly given in our issue of March 15th and April 12th. The statement that the normal expansion of steam may be utilized by a radically new method, calls for the exposition of three things, viz., the actual form of this cycle, how and to what extent it is possible to use steam expansively at a continuous flow, and what adaptation of mechanical means has accomplished in the single stage engine such high results.

An understanding of the charts which illustrate the cycle may be helped by a brief account of how the steam operates in the multi-stage unit. In the first stage the flow of steam alone is used as pressure against the tooth pistons, discharging into the surrounding chamber with a pressure drop and an instantaneous change of volume. It is directed, without change of temperature or pressure, into the confining centerpiece of the next pair of gears where the work of the second stage is done. While doing the work the flow is continuous, but the volume has been increased over that in the first stage, and thus it is plain that a percentage of expansion is obtained. The construction of the compound engine provides an allowance for just that degree of change in volume which will enable an equal amount of work to be performed in each stage against the piston area.

The "stepping down" from one stage to four stages is shown in chart No. I, a pressure volume diagram. Since the steam does not change in temperature or pressure while doing the work in each stage, it can be seen that the principle of the cycle is non-adiabatic. The form which this cycle takes is shown by the shaded outline, as opposed to the curve BC, which represents adiabatic expansion of the Rankine cycle.

A steam pump, a full stroke engine, or the single stage gear engine, uses only the flow of steam, or about 50 per cent of the efficiency of the Rankine cycle, the difference being that in the gear engine the flow of steam is continuous. In chart No. I this flow of steam (work of one stage Clark cycle) is represented by A^1ABD. Its cycle efficiency compared with Rankine is low, but with additional stages increases very greatly. It is important to bear in mind that accurate tests have shown that a very high percentage of the theoretical work of its own cycle is obtained at the brake, which enables the steam economy of even the single stage unit to equal that of the average piston or multi-stage turbine of equal horse-power. In the light of this fact a comparison of the Clark cycle with the Rankine can argue no disadvantage, even though the former equals the ideal Rankine only in an infinite number of stages.

The increase, with additional stages, of the efficiency of the Clark cycle versus Rankine is shown in chart No. II. Note that the expansion line T′ represents the percentage of Rankine obtained by the largest sized turbines. When superheat is used the cycle efficiency versus Rankine rapidly increases, as well as the efficiency of the engine to its own cycle. Chart No. II shows fairly accurately the efficiency of any number of stages under any condition, whether of steam quality, pressure or superheat.

The lack of mechanical losses is one of the chief factors in accounting for the high efficiency of the engine. Like the turbine, it has a straight Willans line. The handling of a large volume of steam is not required of the last stage, for the construction allows nearly all the steam to expand more than once on one or more of the upper stages, and to exhaust directly therefrom to the air or into a condenser.

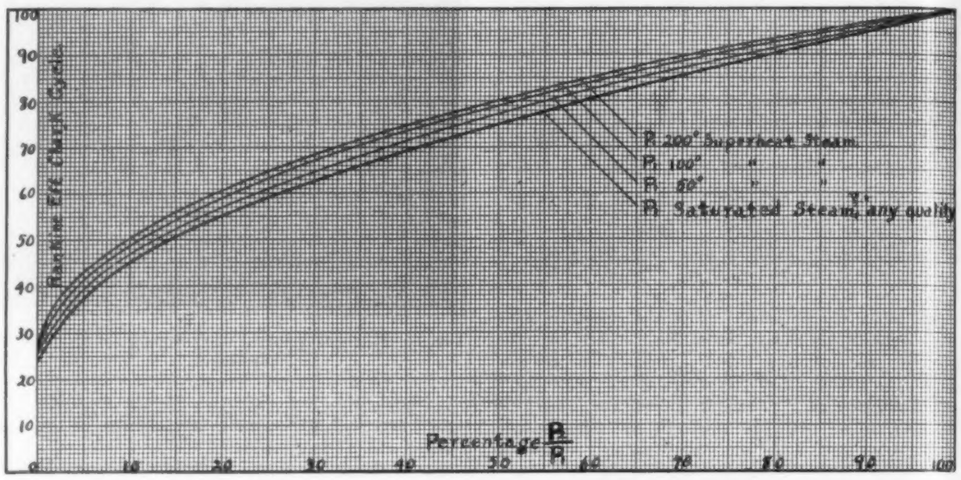


Chart II.—Clark Cycle Versus Rankine Cycle.

This chart shows the Rankine efficiency of Clark cycle for any number of stages regardless of superheat, quality or pressure of steam.

Example: What is the Rankine efficiency of a four-stage Clark cycle; 115—14.7 lbs. abs.?

Total B.T.U. adiabatic drop .... = 150 B.T.U.
One quarter of total adiabatic drop = 37.5 B.T.U.

Pressure corresponding to first 37.5 B.T.U. drop .... = 72 lbs. abs.

$$\frac{72\text{ lbs.}}{115\text{ lbs.}} = \frac{P_2}{P_1} = 62.6\text{ per cent.}$$

62.6 per cent pressure drop....... = 81.75 ran. eff.

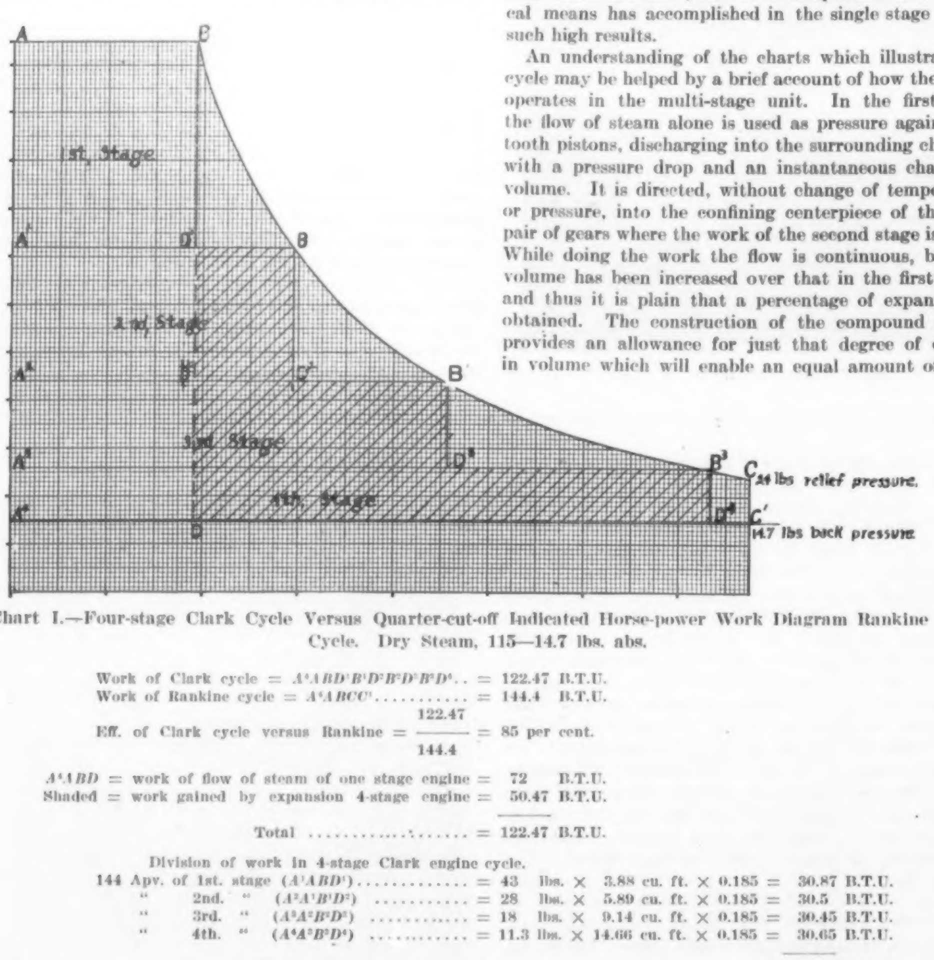


Chart I.—Four-stage Clark Cycle Versus Quarter-cut-off Indicated Horse-power Work Diagram Rankine Cycle. Dry Steam, 115—14.7 lbs. abs.

Work of Clark cycle = $A^4ABD^1B^1D^2B^2D^3B^3D^4$.. = 122.47 B.T.U.
Work of Rankine cycle = A^4ABCC'........... = 144.4 B.T.U.

$$\text{Eff. of Clark cycle versus Rankine} = \frac{122.47}{144.4} = 85\text{ per cent.}$$

A^1ABD = work of flow of steam of one stage engine = 72 B.T.U.
Shaded = work gained by expansion 4-stage engine = 50.47 B.T.U.

Total .... = 122.47 B.T.U.

Division of work in 4-stage Clark engine cycle.

144 Apv. of 1st. stage	(A^1ABD^1).............	= 43 lbs. ×	3.88 cu. ft. ×	0.185 =	30.87 B.T.U.
" 2nd. "	($A^2A^1B^1D^2$)	= 28 lbs. ×	5.89 cu. ft. ×	0.185 =	30.5 B.T.U.
" 3rd. "	($A^3A^2B^2D^3$)	= 18 lbs. ×	9.14 cu. ft. ×	0.185 =	30.45 B.T.U.
" 4th. "	($A^4A^3B^3D^4$)	= 11.3 lbs. ×	14.66 cu. ft. ×	0.185 =	30.65 B.T.U.

Total .... = 122.47 B.T.U.

EXPLANATION OF THE CHARTS.

CHART NO. I.

Pressure-volume diagram, showing by means of compared areas the difference (viz. 15 per cent) of the theoretical work of the Clark and Rankine cycles in a one quarter cut-off engine.

CHART NO. III.

The "Mollier" diagram, which has come into extensive use for the study of the action of steam in turbines. Horizontal lines are lines of constant total heat, showing the change in the condition of steam which results from throttling.

Vertical lines are lines of constant entropy, therefore, the vertical distance between two pressures of the chart represents the work in B. T. U. given up by adiabatic expansion.

Thus, for example, the vertical distance between 115 and 14.7 pounds absolute pressure, measured along the heavy line marked "Adiabatic Expansion Line 100 per cent Rankine," and transferred to the measuring scale on the left of chart No. III, shows that 150 B. T. U. are given up by such adiabatic expansion.

This total heat drop of 150 B. T. U. is, in a four-stage Clark cycle, divided into four drops of 37.5 B. T. U. each, corresponding to the following pressure drops, as found on the Mollier diagram shown in chart III.

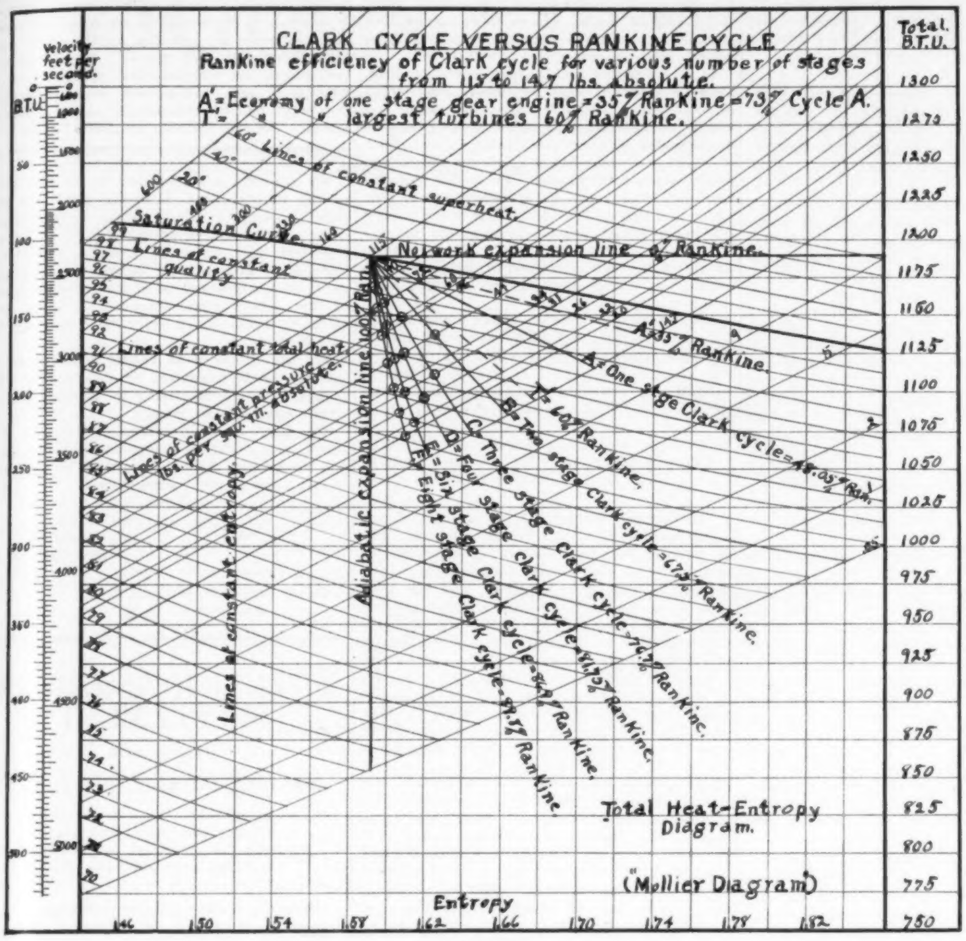


Chart III.

First stage, 150 to 72 pounds absolute; second stage, 72 to 44 pounds; third stage, 44 to 26 pounds; fourth stage, 26 to 14.7 pounds absolute pressure. All these figures are easily located on the "Mollier" diagram by running the eye along one of the lines of constant pressure (which run diagonally upward toward the right) from the point selected on the adiabatic expansion line, up to the heavily drawn saturation curve, along which will be found the figures designating each of the constant pressure lines.

A convenient method for calculating the work of a Clark cycle for successive stages, after the pressure drops have been found as indicated, is as follows:

Assuming for example that the pressure in the boiler is 115 pounds absolute (dry steam), we find from steam tables that the total heat is 1188.8 B. T. U. for one pound, i. e., for 3.88 cubic feet of steam.

Similarly for the second stage, at 72 pounds absolute, steam tables give (dry steam):

Heat of liquid* in one pound of steam, 274.5 B. T. U.
Latent Heat, 905.8 B. T. U.

Volume of one pound of steam, 6.04 cubic feet.

The effective pressure in the first stage is 115 — 72 = 43 pounds.

If x = actual volume of 1 pound of steam in cubic feet in second stage, so that $\frac{x}{6.04}$ = quality of steam, we have therefore by the equation:

Total heat per pound of steam, of second stage = total heat per pound, of first stage — work per pound of first stage.

$$274.5 + 905.8\,\frac{x}{6.04} = 1188.8 - \frac{3.88 \times 43 \times 144}{778\dagger}$$

$$274.5 + 149.8\,x = 1188.8 - 30.87$$

$$x = 5.89 \text{ cubic feet.}$$

$$\frac{x}{6.04} = 97.6\% \text{ quality.}$$

$$1188.8 - 30.87 = 1157.93 \text{ B. T. U. total heat.}$$

Condition of steam of second stage at 72 lbs. absolute.

New York City. C. H. CLARK.

* Heat spent in raising one pound of water from 32 deg. Fahr. to boiler temperature, namely, 305 deg. Fahr., corresponding to 115 pounds absolute measure.

† The factor 778 converts work measured in foot pounds into work measured in B. T. U.

Artificial and Genuine Patina

ANY coloring given to a metal by other means than painting or coating with another metal, says *Die Goldschmiede Zeitung*, is called artificial patina; the coating which forms of itself upon bronze when exposed to the air, is called natural or genuine patina. A good patina not only beautifies the surface of the metal, but protects it from injury. The tones of color vary greatly with the composition of the metal; bronze which contains about 10 per cent of tin takes on the best patina.

Artificial brown patina is produced by smearing the metallic object with a solution of small quantities of silver and copper in dilute nitric acid, and burning this off over a fire. A solution of copper alone in nitric acid will also produce a brown color when burned, but the addition of silver makes a finer one. Still another method of coloring bronze objects brown, is as follows: Dissolve 30 grammes of salammoniac and 10 of acid oxalate of potassium in 250 cubic centimeters of vinegar, and smear the metal repeatedly with this solution. In case the objects are soldered with tin, which would not stand burning, it is better to use a solution of hepar sulphur in water (1 part to 30). Pour the solution into shallow clay or porcelain vessels and hold the object over it; the fumes of hydrogen sulphide which will be developed will color them brown by coating them with copper sulphide. This process is best carried on in a room closed against drafts of air.

Green patina on bronze can be obtained by using a solution of 15 grammes of salammoniac, 30 of tartar, and 60 of common salt, in 250 cubic centimeters of vinegar, to which is added, after the first-mentioned constituents have been dissolved, 80 grammes of a solution of copper nitrate. Smear the objects with the solution and let dry. This method is well adapted to copper, bronze and brass. After the metal is dry, brush it with oil or apply a dull varnish. Another method, and a simple one, of obtaining a greenish patina, is to hold the metal over ammonia fumes; a brownish coating, with a tinge of green, will be quickly formed. The metal should be brushed while moist, and then rubbed dry.

To make a steel-gray patina, immerse the metal in a pickle composed of 500 grammes of hydrochloric acid and 500 of water, mixed with 75 grammes of iron hammer-slag and 75 of powdered antimony sulphide. A steel-gray color can also be obtained by simple immersion of the metal in a solution of antimony chloride. This solution has many other practical uses; it is employed to color zinc black, or to make black markings on it; and, dissolved in linseed oil, it is used for browning iron.

The formation of genuine patina is not unattended by labor. The varying composition of metals will cause variety in the coloring, and this fact must be taken into consideration. A bronze, for instance, in which copper predominates, will acquire a different shade of patina from one containing much zinc. First of all, the metal must be thoroughly cleansed. This is best done, in the case of small objects, by immersion in weak potash lye, and subsequent rinsing in water. After this, the objects are to be placed where an even temperature can be maintained, and where carbonic acid is present in quantities in the air. Small objects are to be immersed in water containing one or two per cent of acetic acid, or in pure vinegar diluted with four or five parts of water; large ones can be sprayed with the fluid by means of an atomizer, twice a day. After a few days, a coating of copper acetate will be formed, which, as the objects remain exposed to the carbonic acid of the surrounding air, changes to a firmly adhering layer of copper carbonate, the so-called genuine patina. If the vinegar solution is made very weak, the patina will form more slowly than otherwise, but its color will be finer. As soon as the coating shows green, the solution may be used in greater dilution, or pure water applied instead. The formation of the patina will then go on of itself, under the influence of the carbonic acid gas. The whole process is of two or three weeks' duration. This method may seem somewhat slow, but it is to be recommended for obtaining a lasting patina. If a room in which the objects can be exposed to carbonic acid gas is not available, they can be patinized by the methods described above, which give not only beautiful but durable coatings, which are hardly to be distinguished from the genuine patina.

Recent Tests of the Cost of Electric Cooking

A thorough study of the cost of electric cooking for a family of six persons for a period of ten days was made recently. The range was wound for 220-volt service and contained two 10-ampere and three 20-ampere switches controlling corresponding baking and stove circuits.

In the table which is printed below are given the character of meal, materials cooked, maximum demand in kilowatts, consumption of energy in kilowatt-hours and cost per meal, the data commencing with the installation of the electric range. The cost of electrical energy is figured at 5 cents per kilowatt-hour. No previous experience had been had with electric cooking. Records were taken by a pen-recording wattmeter which was carefully calibrated with an instrument of precision. Much care was taken to keep the range absolutely free from dirt during the progress of the cooking tests.

COST OF ELECTRIC COOKING, FAMILY OF SIX, AT 5 CENTS PER KW-HOUR.

Meal	Materials Cooked by Electric Range.	Maximum Demand in Kilowatts.	Kw-hours Required.	Cost, Cents
Dinner	4.5 lb. roast lamb; baked white and sweet potatoes; baked rice pudding	2.4	2.7	13.5
Breakfast	Oatmeal; baked apples, 8; coffee	2.24	2.5	12.5
Lunch	Stewed prunes; tea; potatoes for yeast	0.6	0.87	4.3
Dinner	Clock mechanism disconnected	....	....	....
Breakfast	Oatmeal; coffee kettle of water	2.46	1.4	7.0
Lunch	Warming potatoes; finnan haddie warmed; tea	2.2	0.65	3.25
Dinner	3.5 lb. veal roast; baked sweet potatoes; 10 baked apples; baked Irish potatoes	2.8	4.35	21.75
Evening	Cooking oatmeal	1.0	0.47	2.35
Breakfast	Warming oatmeal; coffee	0.68	0.55	2.75
	Testing oven, raising temperature from cold to hot	1.4	0.7	3.5
Dinner	Stewing 4.5-lb. chicken; boiled potatoes; toast	2.08	2.0	10.0
Breakfast	Baked apples, 8; oatmeal; coffee; baking bread; stewing prunes	2.6	3.20	16.0
Lunch	Boiled potatoes; coffee; 3-lb. pot roast	....	3.15	15.75
	Warming coffee; laundress 2 p. m.	0.05	0.1	0.5
Dinner	Boiled sweet potatoes; baked potatoes; baked cornbread	2.4	2.75	13.75
Breakfast	Coffee; oatmeal	1.0	0.55	2.75
Dinner	Beef stew; carrots; potatoes; prune stew	2.0	2.5	12.5
Breakfast	Baked apples; oatmeal	2.48	2.55	12.7
Lunch	Warming meat and coffee	1.4	0.7	3.5
	Baking three loaves graham bread	1.28	1.35	6.75
Dinner	Chicken stew, 4.5 lb.; cranberries, 1 qt.; potatoes, boiled (6 large)	1.00	2.15	10.75
Breakfast	Baked apples, oatmeal; coffee	2.5	3.25	16.25
Lunch	Warming meat; coffee	1.6	0.35	1.75
Dinner	Meat pie; potatoes boiled	2.2	2.5	12.5
Breakfast	Oatmeal; coffee	0.6	0.6	3.0
Lunch	Warming meat; coffee; potatoes for yeast	0.90	0.6	3.0
Dinner	Baked finnan haddie; boiled potatoes; baked apple, cream sauce	2.60	3.5	17.5
Breakfast	Baked apple; oatmeal; coffee	1.0	0.5	2.5

Experience showed that some energy was lost by changing from one heat to another in order to regulate the temperature properly. It was found that after the oven was once heated, baking could be done at a small cost. Roughly, the cost of electric cooking varied from 3 cents to 10 cents per day per person upon the basis of the above rate per kilowatt-hour.—*The Electrical World.*

NEW BOOKS, ETC.

TECHNISCHES AUSKUNFTBUCH FUER DAS JAHR 1913. Joly. Zwanzigste Auflage. (Ca. 1600 S., zahlreiche Abbildungen.) Leipzig: K. F. Köhler, 1912. Preis geb. 8 M.

This book of technical information, which has reached its twentieth edition, has been prepared on a novel plan. It gives the prices of technical products and names the manufacturers from whom those products may be obtained. No advertising of any kind appears in the volume. Hence the author is enabled to present his information without being influenced by what are euphemistically called "business considerations."

Joly may be regarded as a supplementary volume to "Huette," a well-known engineering handbook widely used in Germany. It is a handy technical lexicon for the engineer and architect. To compress in a handbook all the commercial information that an engineer requires is no light task. That Joly should have succeeded so well is simply astonishing. To be sure, there are omissions (Blaugas, for example, is not mentioned), but the wealth of information contained in the volume bears ample testimony to the diligence and conscientiousness of the editor.

INDEX OF MINING ENGINEERING LITERATURE. By Walter R. Crane, Ph.D. New York: John Wiley & Sons, 1912. 8vo.; 445 pp. Price, $4 net.

This issue of the Index covers the same ground as the first volume, with the addition of a number of new publications. It is especially commendable for its system of cross-references and multiple references, and for its wealth of material on the subject of cost, which covers almost every phase of mining and metallurgical practice. These desirable features will be appreciated by the practising engineer.

STRENGTH OF MATERIALS. A Textbook for Secondary Technical Schools. By Mansfield Merriman. New York: John Wiley & Sons, 1912. 12mo.; 169 pp.; illustrated. Price, $1 net.

Students in the higher classes of manual training schools have been kept particularly in mind in the preparation of this work, and the lessons are so presented as to dispense with the calculus, and to require only a knowledge of arithmetic, algebra, geometry, and elementary mechanics. Rules are given for the study and the designing of common beams by simple algebraic and geometric methods.

GEM STONES. By G. F. Herbert Smith, M.A., D.Sc. London: Methuen & Co., Ltd., 1912.

DIE SCHMUCK UND EDELSTEINE. Von Dr. A. Eppler. Stuttgart, Verlag Felix Krais, 1912.

Two new books on Gems have recently appeared: One, "Gem Stones," by Dr. Herbert Smith, in English; the other, by Dr. Alfred Eppler, in German.

Dr. Smith gives a good description of gem characteristics and discusses the technology of gem stones, precious and semi-precious stones, etc., and gems of organic products, such as pearls, corals, and amber. The book is well illustrated. It gives the reader information on manufactured stones, but not as much as he would expect or desire. Mining is well described and illustrated. The gem minerals treated in regular manner give much solid information to the reader. To give the complete history of all the many various gems, both precious and semi-precious, of gem minerals, of ornamental stones, and of manufactured gems, would undoubtedly aid the student considerably, but considering the amount of space such a work would require, one is thankful even for such information as the book includes. "Gem Stones," by Dr. Herbert Smith, deserves praise, and fulfills the demand for a student's textbook.

A valuable reference book for the jewelry trade at a very reasonable cost is "Die Schmuck und Edelstein" of Dr. Alfred Eppler. Dr. Eppler is well known to us by reason of his excellent instructive articles in various trade papers. Many excellent books are mines of information, but generally fail, inasmuch as they assume too much knowledge on the part of the reader or are so hedged about with technical formulæ that many are affrighted at the prospect of spending in their perusal more time than business leisure will afford. Without in the least losing sight of the prime mineralogical essentials to a good working knowledge of precious stones, Dr. Eppler has produced a book which will undoubtedly help the student. His book is not likely to disappoint, for it is full of sound information, clearly presented. The chapter devoted to manufactured stones is sure to attract a good deal of notice. Never before has such a complete, concise, and accurate account appeared in any work dealing with precious stones. Diagrams and photographs of the apparatus used in the process enhance the value of this treatise considerably. Here the reader will learn exactly what the laboratory has produced in the way of artificial gems, and, what is of equal importance, what it has failed to do. The diamond, ruby, emerald, sapphire, beryl, and morganite are described at length. Another part is devoted to a description of the various gem minerals separately. The diamond, as well as the bonamite, epidote and ruby, the apricotine, the dewylite, the emerald, and the alexandrite are all classified and thoroughly described. The colored plates make the book still more attractive. "Schmuck und Edelstein" is undoubtedly a book which not only completely fulfills the demands for a student's, minerologists', and jeweler's textbook, but also provides an invaluable assistance and work of reference for every individual member of the profession.—E. F.

LA MER. Par M. Clerc-Rampal, Vice-president du Yacht-Club de France. Avec preface de M. A. Berget, professeur à l' Institut Océanographique. Paris: Librairie Larausse, 1912. Fascicules 1 à 13.

In his gracefully worded preface to this interesting work on the Sea, which appears in installments, Prof. Berget of the Oceanographic Institute tells us that the subject will be discussed from two points of view, the "Sea in Nature" and the "Sea and Humanity." The thirteen installments which lie before us cover the "Sea in Nature" and are entirely scientific in character. If we may judge from these, the completed work will be a unique and extremely valuable publication. The articles are well written and lavishly illustrated; the printing is excellent. The subjects discussed in the installments here noticed are the following: The Origin of Oceans; Geography of the Sea; Chemistry of the Sea; Depth of the Sea; The Bottom of the Sea; Temperature of the Sea; Ice and the Sea; The Meteorology of the Sea; Marine Currents; Wave Interference; Cyclones and Typhoons, etc.

Although the book is intended primarily for general reading and reference, it contains so much of scientific value that it may be regarded as an important contribution to a subject the various phases of which are discussed in widely scattered books and periodicals. The excellent colored illustrations and the carefully prepared and printed maps bear testimony to the great pains which have been taken to publish a work which will be of permanent value.

HANDBUCH FUER HEER UND FLOTTE. Enzyklopaedie der Kriegswissenschaften und verwandter Gebiete. Herausgegeben von Georg von Alten, Generalleutnant z.D. Berlin: Deutsches Verlagshaus Bong & Co., 1913.

Installments 55 and 56 take us from *Gruppenblinckfeur* to *Harnisch*. The principal articles in these installments deal with the military achievements of the Hapsburgs, Hamburg as a seaport, small firearms, the House of Hanover and its wars. Americans will read with particular interest the article on Hampton Roads, in which the important naval engagements that there took place during the Civil War are discussed.

TRUCK AND TRACTOR. The Coming of Cheaper Power for City and Farm. By Herbert N. Casson, L. W. Ellis, and Rollin W. Hutchinson, Jr. Chicago: F. G. Browne & Co., 1913.

The three authors of this book have collaborated to show that the horse is doomed to disappear for most farm work and city haulage because he is too expensive. All three men write from the dollars and cents point of view—Mr. Casson on broad national lines; Mr. Hutchinson on the possibilities of the motor truck as a freight hauler, and Mr. Ellis on mechanical plowing. Mr. Ellis has written perhaps the most valuable portion of the book; for his contribution is manifestly based upon intimate personal first-hand knowledge of the farmer's requirements.

DER ENERGETISCHE IMPERATIV. Erste Reihe. Leipzig: Akademische Verlagsgesellschaft, 1912.

Ostwald's *Der energetische Imperativ* may be regarded as a continuation of his *Die Forderung des Tages*. The book is divided into five parts devoted to philosophy, organization, internationalism, teaching systems, biographical sketches.

In his introduction Prof. Ostwald explains how from a dualist believing in matter and energy, he became a monist, and how the conception of energy ultimately came to dominate him. As in all his writings, Ostwald insists upon the value of science in the development of civilization, placing it far above politics, art, and even religion. But he concedes that science can never take the place of the will. It may show us the right path to travel, but it remains for the will to decide whether or not that part will be followed. Science must above all things be useful. The past and the present must be known in order that the future may be predicted. Ostwald adopts with some modifications Auguste Comte's classification of the sciences, and distinguishes logic and mathematics, which are based upon the notion of order, the physical sciences founded on the notion of energy, and lastly the biological sciences, which are devoted to the study of life and its manifestations. The living being is a complex organization in which energy is allowed free scope to permit the individual to preserve himself and to propagate his species. All values are derived from the law of the dissipation of energy. The transformation of energy from one form into another leads us to the notion of efficiency in the utilization of energy. "Don't waste energy; use it," is Ostwald's doctrine, constantly uttered. By carrying out that doctrine into practice, Ostwald hopes to show that the monist, so far from being a dreamer, is a strict utilitarian. In that doctrine is summed up the whole science of life and the art of living Out of this idea grew Ostwald's "Bruecke," a scheme for the scientific management of scientists, intended to prevent unnecessary repetition of the same investigations and researches. Since the saving of energy means so much to him, Ostwald is naturally a champion of international peace.

In his chapters on our pedagogic system, Prof. Ostwald reiterates what he already dwelt upon in his "Grosse Maenner." Our university and school systems of teaching are inefficient. Ostwald distinguishes between the matter and the form of teaching, between what should be taught and how it should be taught. He would separate teaching from scientific investigation—a plan which has already been at least partially carried out and with considerable success in this country. The budding genius is to be given a chance; at present the high school and the university constitute intellectual strait-jackets in which he is confined.

Everything that Ostwald writes is stimulating. Curiously enough, his views are more readily accepted in foreign countries than in Germany. But after all, that is to be expected wherever we find that academic principles dominate even the lowliest forms of human activity.

ELEMENTS AND ELECTRONS. By Sir William Ramsay, K.C.B., F.R.S. London and New York: Harper & Bros., 1912. 173 pp.

Sir William Ramsay's fame as one of the pioneer students of the radioactive substances as well as the discoverer of the spontaneous production of helium from radium renders any popular book of his of interest. In this little volume, a splendid example of good popular scientific writing, the lay reader will find the development of chemical theories excellently sketched and our knowledge of the radio-active substances outlined. Naturally, that portion of the volume which deals with transmutation will be read with the liveliest interest, in view of Sir William Ramsay's recent announcement. Although Sir William is one of the prophets of transmutation, he discusses the subject very conservatively indeed for him. What is more, he discusses it very fairly; for in recounting his remarkable discovery of the transformation of copper into lithium, he frankly states that Madame Curie was unable to confirm his own results. So formidable is the array of evidence in favor of transmutation, that it is difficult indeed to see why Sir William's views should be so skeptically received in many quarters.

THE FIXED LAW OF PATENTS. By William Macomber. Second edition. Boston: Little, Brown & Co., 1913.

It is a pleasure indeed to see that Mr. Macomber's excellent "Fixed Law of Patents," a digest of important decisions by the Supreme Court of the United States and the nine Circuit Courts of Appeals, has proved so popular that it has passed into a second edition. Mr. Macomber has seized the opportunity of revising his book. Not only are the decisions in the Expanded Metal case, the Mimeograph case, and the Westinghouse Transformer case included, but more or less extensive revisions have been made which bring the work up to date. In this digest the patent lawyer will find the leading principles of patent law enunciated in the language of authoritative courts. Only a skilled patent lawyer could undertake this work, for the principles of patent law are peculiar in themselves, and demand special knowledge. Mr. Macomber's wide familiarity with the subject admirably fitted him for this task. His book must be regarded as a volume which every patent lawyer will place side by side with the time-honored "Robinson on Patents."

A HANDBOOK OF PHYSICS. By W. H. White, M.A., B.Sc., Lecturer in Physics at the East London College and at St. Mary's Hospital Medical School, and Examiner in London University. With over 300 diagrams. London: Methuen & Co., Ltd., 1912.

A COURSE OF PHYSICS, PRACTICAL AND THEORETICAL. By Charles H. Draper, B.A., D.Sc. London: Blackie & Son, Ltd., 1912.

In his preface, Mr. White tells us that "this book, written in response to constant appeals from my students, covers the requirements of the first or intermediate examinations of the universities, a stage which demands a very fair general knowledge of the subject and one beyond which it is nowadays undesirable to trust to a single treatise." His book is, therefore, to be regarded as a volume to be used in connection with a fairly advanced course of lectures. Judged in this light, Mr. White's book must commend itself to every teacher. The subject is discussed from the usual lecturer's standpoint. There are divisions on mechanics, heat, wave motion, sound, light, magnetism, electricity, and magnetism and electricity. At the end of each chapter will be found questions, and in the back of the book the answers to the questions, an arrangement which has the advantage of preventing the pupil from simultaneously reading a question and answer. A good index is supplied.

Mr. Draper's book is of a more elementary character. While it covers very much the same ground, it is devoted almost entirely to the rudiments of physical science. The book is a textbook which is to be used by the pupil to the accompaniment of experimentation. A series of admirably planned exercises is presented, calculated to test the pupil's ability and reasoning powers. Unlike most textbooks, it allows for the quick and the slow pupil; for in addition to exercises to be carried on by all pupils, additional exercises are provided for the pupils who work faster than their fellows. The laboratory instructions are supplemented by descriptions, definitions, and explanations which enlighten the pupil on the theoretical side of physical science. Graphic methods are insisted upon.

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, MAY 17, 1913

Published Weekly by Munn & Company, Inc.
Charles Allen Munn, President
Frederick Converse Beach, Sec. and Treas.
All at 361 Broadway, New York

Entered at the Post Office of New York, N. Y.
As Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year . . .	$5.00
Scientific American (est. 1845) " . . .	3.00
American Homes and Gardens "	3.00

The combined subscription rates and rates to foreign countries including Canada, will be furnished upon application.

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 361 Broadway, N. Y.

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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